TN
939
G33
v.22
c.1
ENGS
Min. Mat
1937
ENGR STORAGE

T. Eastwood

MEMOIRS OF THE GEOLOGICAL SURVEY.

Lead Deposits in Penmaen W.W Varvill
Halkyn Mines J.B Richardson

SPECIAL REPORTS ON THE MINERAL RESOURCES OF GREAT BRITAIN.

VOL. XXII.—THE LEAD AND ZINC ORES OF THE LAKE DISTRICT.

BY

T. EASTWOOD, A.R.C.S.

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HIS MAJESTY'S TREASURY.

LONDON:
PRINTED UNDER THE AUTHORITY OF HIS MAJESTY'S STATIONERY OFFICE.

To be purchased from
E. STANFORD, LTD., 12, 13 and 14, LONG ACRE, LONDON, W.C.2;
W. & A. K. JOHNSTON, LTD., 2, ST. ANDREW SQUARE, EDINBURGH;
HODGES, FIGGIS & Co., LTD., 20, NASSAU STREET, and
17 and 18, FREDERICK STREET, DUBLIN;
or from any Agent for the sale of Ordnance Survey Maps; or through any Bookseller, from the DIRECTOR GENERAL, ORDNANCE SURVEY, SOUTHAMPTON.

1921.

Price 2s. Net.

See Report of the
Advisory Com. for Metr. Mining & Quarrying
Mines dept. 1932. 3rd

Outputs, Prices do.

MEMOIRS OF THE GEOLOGICAL SURVEY.

For History see History of Mng - Cumb & N. Lancs
by T D Kendall, Trans N.E Min Eng (1985) vol 35)

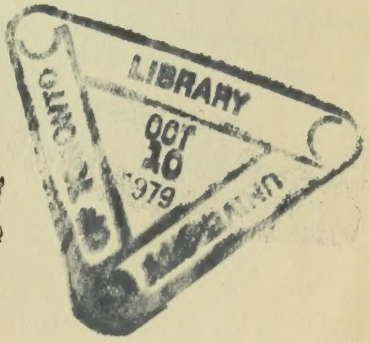
SPECIAL REPORTS ON THE MINERAL RESOURCES OF GREAT BRITAIN.

VOL. XXII.—THE LEAD AND ZINC ORES OF THE LAKE DISTRICT.

BY

T. EASTWOOD, A.R.C.S.

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HIS MAJESTY'S TREASURY.



LONDON:
PRINTED UNDER THE AUTHORITY OF HIS MAJESTY'S STATIONERY OFFICE.

To be purchased from
E. STANFORD, LTD., 12, 13 and 14, LONG ACRE, LONDON, W.C.2;
W. & A. K. JOHNSTON, LTD., 2, ST. ANDREW SQUARE, EDINBURGH;
HODGES, FIGGIS & CO., LTD., 20, NASSAU STREET, and
17 and 18, FREDERICK STREET, DUBLIN;
or from any Agent for the sale of Ordnance Survey Maps; or through any Bookseller, from the DIRECTOR GENERAL, ORDNANCE SURVEY, SOUTHAMPTON.

1921.

Price 2s. Net

Digitized by the Internet Archive
in 2010 with funding from
University of Toronto

http://www.archive.org/details/specialreportson22geol

PREFACE.

The district of which the lead and zinc veins are described in this memoir is composed mainly of the older Palæozoic rocks, and is well defined both in its geological and in its geographical relationships. For this reason it has seemed convenient to treat it as a separate area. Its mineral deposits present several peculiarities which distinguish them from those of the surrounding Carboniferous strata. None of the deposits of this area has proved to be of large size or exceptionally productive, but several of them have been worked from a very early time, and there are five or six active mines in the district at present. Many interesting problems are presented by the paragenesis of the minerals in the lodes, but much remains obscure regarding their origin and history.

The author desires to make acknowledgment of assistance rendered by Mr. Anthony Wilson and his staff at Thornthwaite and Threlkeld Mines, Mr. W. H. Borlase and staff of Greenside Mine, Mr. Stretton of Force Crag, Mr. J. Hemingway of Mungrisdale, and Messrs. J. Postlethwaite and B. Johns of Keswick.

The memoir has been edited by Mr. Bernard Smith.

JOHN S. FLETT,
Director.

Geological Survey Office,
28, Jermyn Street,
London, S.W.1.
31*st May*, 1921.

x x (78)14437 Wt 1395—59/968 750 8/21 A 2

CONTENTS.

	Page
Preface by the Director	iii
Chapter I.	
General Account	1
Chapter II.	
Detailed Descriptions of the Mines	6
Section 1.—Working Mines (1919)	6
Section 2—Abandoned Mines and Trials	26

Illustrations.

Text Figures.

Fig. 1.—Geological Sketch Map of the Lake District, showing distribution of Lead and Zinc Mines - - - 4

Fig. 2.—Diagrammatic Sketch Plan of Greenside Mine to show shifting of the lode by east and west faults - 16

Fig. 3.—Diagrammatic Sketch Plan of Goldscope Mine along the adit, showing shifting of east and west copper-lode by north and south lead-veins - - - 24

Fig. 4.—Sketch Map of Drygill, showing shifts of the east and west lead-lode by north and south veins, which carry tungsten in the greisen farther south - 42

Plate.

	Facing Page
Plate I.—Outputs of Blende and Galena	26

THE LEAD AND ZINC ORES OF THE LAKE DISTRICT.

CHAPTER I.

GENERAL ACCOUNT.

The English Lake District, a mountain group that falls within the counties of Cumberland, Westmorland and Lancashire (Furness), has been well mineralised, but although there are innumerable veins carrying ore of some kind, the number that can be considered productive under modern conditions is comparatively small.

Mining[1] has been carried on sporadically for hundreds of years: as a copper-producer[2], the district had an excellent reputation in Elizabethan times and was of considerable importance: the output of lead, and still more of zinc ores, is of more recent date.

The Mineral Fields.—Lead-ores are found in three main regions:—(1) Keswick, (2) Helvellyn, (3) Caldbeck Fells.

In the Keswick field the veins traverse folded shales and mudstones interbedded with thin sandstones. These strata belong to the *Skiddaw Series*, and are of Cambro-Ordovician age.

In the Helvellyn area there is a 'country-rock' of volcanic ashes, tuffs and breccias, interstratified with lava flows and pierced by numerous igneous intrusions. These belong to the *Borrowdale Series*, are exclusively Ordovician, and are younger than the Skiddaw Series.

In the Caldbeck Fells, Borrowdale volcanic rocks again predominate: they are of more basic type than usual, and are known as the *Eycott Series*. At the Drygill Mine, a set of fossiliferous shales and mudstones with bands of lava are now regarded as of late Ordovician (Bala) age, belonging to the Coniston Limestone Group. In no other locality in the Lake District do the Bala strata contain workable veins, and the veins in the still younger (Upper Silurian) Bannisdale Slates, on the south side of the lake country, have so far proved unproductive.

In addition to the sedimentary rocks, there are igneous intrusions (the Skiddaw Granite on the north side of the Keswick field, and gabbro, hypersthenite, felsite, &c., in the Caldbeck Fells) all traversed by metalliferous veins. It is possible that the richness and the variety of the ores in the Caldbeck Fells may have some connexion with the multiplicity of rock types found there.

The Veins.—A few of the quartz veins and strings profusely scattered over the Lake District originated before the crumpling

[1] *See* J. Postlethwaite, 'Mines and Mining in the Lake District,' Ed. 3, 1913.

[2] The copper ores of England and Wales will be described in a special memoir of this series.

movements had ceased, but the great majority of the veins are of later date, and unaffected. In the latter category the metalliferous veins are included; most of them are essentially fault-breccias, impregnated with vein-quartz and gangue 'spars' accompanied by ores of lead, zinc, and copper. They are classified locally as 'lead' or 'copper' veins, according to the dominant mineral. In some of the so-called 'lead' veins, zinc blende is in reality the principal ore, but it is only in comparatively recent times that the value of this mineral has been recognised.

In all the fields there is a general rule (subject, however, to many exceptions) that veins carrying ores of lead and zinc range within 45° on either side of a north-and-south direction, and hade to the east, while 'copper-veins' trend more nearly east-and-west, hading south.

The Minerals.—The chief lead-ore is galena. It is markedly argentiferous, and the silver content appears to have some relation to the presence of barytes: veins with little or no barytes (Thornthwaite, Threlkeld and Greenside) are low in silver (about 10 ozs. per ton of pig-lead), while in barytes-galena veins, such as Force Crag and Driggith-Sandbeds, the silver content is always high, in fact seldom less than 30 ozs. to the ton. This coincidence seems worthy of attention, although it may well be purely fortuitous.

Lead-ores, other than galena, are unimportant: some cerussite ($Pb\ CO_3$), and pyromorphite ($(PbCl)Pb_4(PO_4)_3$), mimetite ($(PbCl)\ Pb_4(AsO_4)_3$) and kampylite (a mixture of pyromorphite and mimetite) have been got from the superficial parts of the lodes: anglesite ($PbSO_4$) is rare. Stolzite ($PbWO_4$) is found only at Force Crag.

The only zinc-ore of commercial importance is blende: occasionally specimens of calamine ($ZnCO_3$) and hemimorphite ($(ZnOH)_2SiO_3$) have been got at Roughtongill in the Caldbeck Fells.

Copper-ores, while, of course, mainly developed in the so-called 'copper-veins,' frequently occur in 'lead-veins' also, though such cases are of economic value in the Caldbeck region only. They are represented by chalcopyrite, and its various coloured alteration products (malachite, &c.).

There is a certain amount of iron-pyrites in most of the veins; as a rule, it is not in sufficient quantity to interfere with dressing operations, though in the deeper levels of Threlkeld Mine it gave trouble. Limonite is not uncommon: chalybite is occasionally seen. Manganese occurs as psilomelane coating other minerals near the outcrop of a vein.

The chief gangue mineral, everywhere, is quartz: it may be hard and platy; sometimes it is sugary, or like fine sand. The 'spars' are relatively unimportant: barytes is of sporadic occurrence, being usually found in the upper levels of certain veins as at Force Crag. Calcite is rather rare; the chief locality

is Roughtongill (Caldbeck Fells), though it is seen at times at Greenside Mine. Dolomite (Force Crag, Thornthwaite, &c.) is more common, though nowhere plentiful. Fluorspar, so often associated with lead-veins elsewhere, is exceedingly rare in the Lake District; a few small crystals were got recently at Force Crag.

Order of Crystallisation.—The minerals may be arranged in pairs; in each, one member may or may not precede the other. The couple galena-blende usually precedes barytes-dolomite, while iron pyrites and psilomelane appear last of all. The copper-ores are less regular; in the Keswick field chalcopyrite usually precedes galena-blende, but (so far as one can see from fragments on the waste-heaps) the reverse often holds along the Roughtongill-Driggith lode in the Caldbeck Fells.

Quartz, in all the fields, may belong to any period of crystallisation.

Variability of the Lodes.—Both the richness and the character of the lodes are associated with various factors whose influence is little understood. In many veins it has been noticed that an increase in steepness coincides with enrichment, and *vice versâ*. The hardness and chemical composition of the country rock both have their effect. As a rule, moderately hard rocks are better ore-bearers than soft ones, and in very soft rocks the lode is often barren. At Coniston, however, constriction and impoverishment occur in hard hornstones as well as in slate.

Changes of composition in the 'country' have a special significance in the igneous complex of Caldbeck Fells. Acid rocks, such as the quartz-felsite dyke at the north end of Greenside Mine, 'deaden' the veins completely. Sub-basic types (*e.g.*, the dykes at Threlkeld and Brandlehow), and in a still greater degree the basic rocks such as the hypersthene gabbro of Roughtongill, seem to favour the enrichment of the veins that traverse them.

As regards the effects of depth on the ore-bodies, mining in the Lake District is on too small a scale to permit of an extended series of observations. The veins, as a rule, do not bear well much below the main valleys; although there may be rich 'sops,' the ore-bodies generally dwindle and the barren tracts increase with depth. Thornthwaite Vein, however, is an exception to this rule, and Greenside Lode, though not yet wrought below the level of the main valley, shows no sign of deterioration.

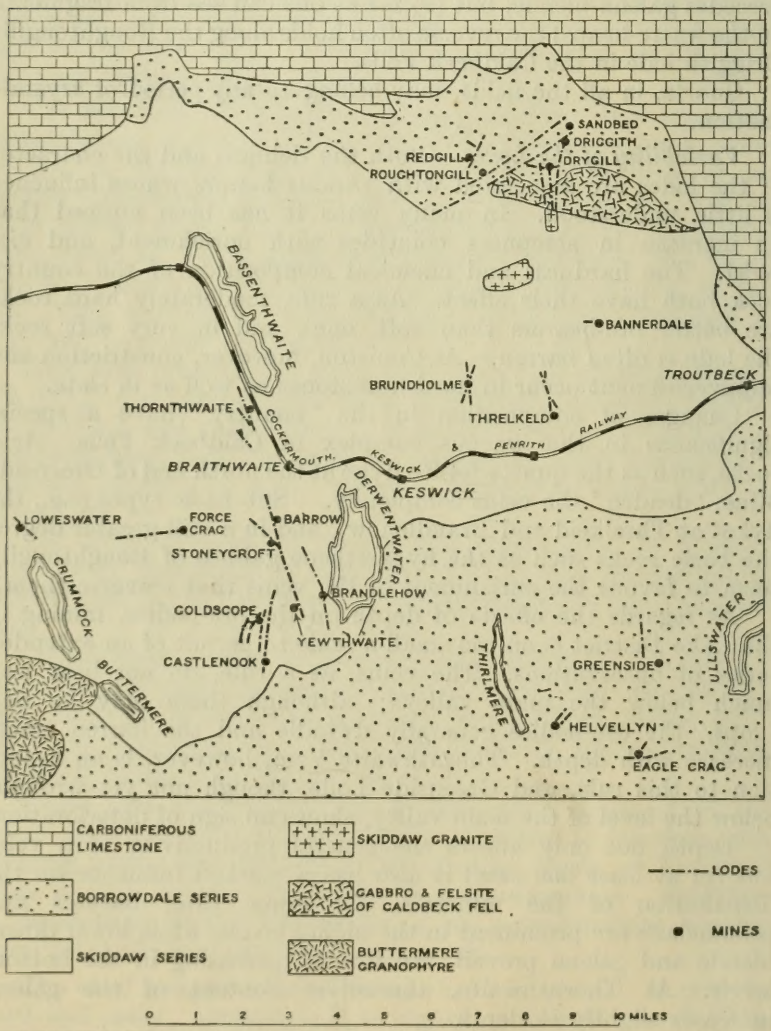
Depth not only affects the general productivity of a vein, but (in at least one case) it also has a marked influence on the distribution of the minerals. At Force Crag barytes and psilomelane are prominent in the higher levels, while lower down, blende and galena prevail, the former increasing in the bottom levels. At Thornthwaite, the silver content of the galena increases slightly in depth.

In common with other regions, enrichment often occurs at the intersection of veins; a dissimilarity in the lodes appears to favour this, an excellent illustration being the discovery

of the ' Great Lead Bunch ' at the intersection of the Goldscope ' lead ' and ' copper ' veins.

Date of Mineralisation.—Although there is evidence as to the relative ages of the various groups of veins, no definite dates can be given. The extension of some of the fault lodes into Carboniferous Limestone strata suggests that they are at least post-Carboniferous, and this is also Dr. Harker's[1] opinion regarding the faults displacing the gabbro at Roughtongill. Analogy with similar rocks in the west of Scotland has led Prof. J. E. Marr[2] to

FIG. 1.—GEOLOGICAL SKETCH MAP OF THE LAKE DISTRICT SHOWING DISTRIBUTION OF THE LEAD AND ZINC MINES.



[1] ' Carrock Fell : a Study in the Variation of Igneous Rock-Masses,' *Quart. Journ. Geol. Soc.*, vol. li, 1895, p. 126.

[2] ' Presidential Address,' *Quart. Journ. Geol. Soc.*, vol. lxii, 1906, p. xc.

suggest a Tertiary age for the complex of Carrock Fell, which is cut by several of the lodes. Mr. J. F. N. Green,[1] on the other hand, maintains that the igneous rocks of Carrock are pre-Bala in age.

The whole question is complicated by the fact that much of the vein contents may be later than the faults along which they occur. The only definite statement possible is that there are at least two, and perhaps three, periods of mineralisation. Examples are given (Figs. 2, 3 and 4) from the Keswick region, showing an east-and-west 'copper-lode' displaced by a north-and-south 'lead' vein, and from the Caldbeck Fells showing an east-and-west 'lead-copper' vein shifted by north-and-south faults, which carry tungsten farther south; in the third, from the Helvellyn region, the barren east-and-west cross-courses which shift the north-and-south 'lead' vein at Greenside may belong to a third and final period.

Mining.—Lead-mining in the Lake District has passed through many vicissitudes, and the only mines at present (1919) in operation are those of Greenside, Thornthwaite, Force Crag, and Threlkeld. Brundholme is not yet fully opened out; at Goldscope or Newlands, the old level is being pushed forward to endeavour to locate the intersection of the 'copper-vein', with 'Sealby's lead-vein,' in the hope of proving a galena 'bunch.' The other mines described are now closed for a variety of reasons. Some, perhaps, are exhausted, whilst others were of little value from the start; but in many cases the reason for failure appears to have been lack of capital—sufficient money being subscribed to start a mine in a small way provided that fairly good ore, that required no elaborate dressing, was found almost immediately. Even when good ore-bodies were found, prospecting for others did not proceed along with development.

The remote situations of most of the mines raise serious transport difficulties, the working cost being especially affected where coal is the power generator. Electricity derived from water-power is used at Greenside, but most of the other mines are not so favourably situated in this respect. There is a fair local supply at Roughtongill, while a larger body of water, though with less fall, can be got from the Caldew.

In all the fields, a power- and motor-transport scheme on a co-operative basis would no doubt be advantageous.

Dressing.—Ore-treatment in the Lake District is usually along normal lines, calling for no special remark: attention may be drawn, however, to the successful separation of blende from barytes at Force Crag, by means of the Elmore flotation process.

Some of the mines in the Caldbeck Fells—such as Drygill, Driggith, and Sandbed—have had difficulty in obtaining, locally, sufficient water for dressing, and in the past were linked up by a system of 'leats' gathering water from springs and streamlets

[1] 'The Age of the Chief Intrusions of the Lake District,' *Proc. Geol. Assoc.*, vol. xxviii, 1917, pp. 1–30.

on the intervening hillsides. If the mines were reopened on a modern scale, this system of ' leats ' would have to be considerably enlarged, or dressing carried out at lower elevations, where water is more abundant.

Smelting and desilverising are no longer carried out locally, the last work of this kind, at Greenside, having closed down during the war.

CHAPTER II.

DETAILED DESCRIPTIONS OF THE MINES.

The courses of the majority of the lodes and the various types of country rock are laid down on the Geological Survey maps published on the scale of 6 in. to the mile; they are shown, in less detail, upon the 1-in. scale. Copies of these maps are available for reference at the offices of the Survey in London and Whitehaven. The sketch-map on page 4 illustrates the general geology and indicates the positions of lead and zinc mines, which are, or have been, of importance in the Lake District.

In the following detailed descriptions, the mines and lodes are arranged in groups :—

1. Mines working in 1919.—Thornthwaite, Threlkeld, Greenside, Brundholme, Force Crag, and Goldscope.

2. Abandoned mines and trials arranged in districts :—

A.—*Keswick Field :* (i) Newlands Vale.—Barrow, Stonycroft, Yewthwaite and Castle Nook. (ii) Derwentwater.—Brandlehow or Brandley. (iii) Skiddaw.—Saddleback, Bannerdale and trials in Keswick area.

B.—*Caldbeck Fells :* Roughtongill, Redgill, Drygill, Driggith, Sandbed and trials in Caldbeck area.

C.—*Helvellyn Field :* Grisedale, Hartsop Hall, Wythburn and Low Hartsop.

D.—*Scattered occurrences :* Loweswater, Windermere and Coniston.

SECTION I.—WORKING MINES.

Thornthwaite Mines.

Situated at the south-western end of Bassenthwaite Lake, close to Thornthwaite Village.

Maps.—One-inch New Series Ordnance, 29; Old Series Geological, 101 S.E.; 6-in. Geological, Cumb., 55 S.E. and 63 N.E.

History.[1]

On this property, within an area about 1½ miles long and half-a-mile broad, there are at least four veins. They all trend in a general N.N.W. direction through contorted Skiddaw Slates, and,

[1] *See* J. Postlethwaite : ' Mines and Mining in the Lake District,' ed. 3, 1913, p. 93.

taken in order from E. to W., are known as the Thornthwaite (the principal lode, and still in work), Rachel, and East and West Ladstock Veins. The old Beckstone Mine, at the northern end of the area, is isolated from the rest, and may possibly have wrought extensions of the Rachel Lode.

There were four distinct mines, from which sufficient ore was raised for a local smelting-works, which remained in operation until 1849. Ladstock is the oldest and began in the pre-gunpowder days of mining, though Beckstone and the crop-workings of Rachel Wood are also very old. The outcrop of the Thornthwaite Lode being on low-lying ground, the vein could not be attacked by adit, but required a shaft, which was 27 fms. deep in the early days of last century.

In 1848, the 'Keswick Mining Co.' reopened Thornthwaite Mine and treated the old dumps of Beckstone, but operations did not extend beyond five or six years. In 1873, Mr. W. Francis took over the mines and reopened Ladstock. The 'Keswick United Silver Lead Mine Co.' was next formed, and Thornthwaite reopened. In 1875, the Rachel Wood cross-cut was commenced, but abandoned before reaching the veins. Mr. J. B. Lobb took over the property in 1881, under the title of 'The Cumberland Lead Mine Co.' The shaft was deepened to 50 fms. and a more efficient plant erected.

After the death of Mr. Lobb, the mine was transferred to the present proprietors—'Thornthwaite Mines, Ltd.'—under the direction of Messrs. F. C. Crewdson and A. Wilson,[1] who have pushed forward the abandoned Rachel Wood cross-cut and developed the mine considerably.

Geology.

The 'country' of the mining belt consists of dark sandstones and shales, partly cleaved, highly contorted and probably smashed by numerous faults of small throw. It is everywhere traversed by small irregular strings of quartz, though these are not regarded as 'feeders' by Messrs. Wilson and Turner. J. Postlethwaite mentions[2] "thin dykes or sheets of intrusive trap (diorite?) which intersect, and no doubt enrich the veins," but, so far as we know, the only igneous rock seen in the field is the narrow dyke of dolerite running from N.E. to S.W., through the higher part of Rachel Wood, and this has not yet been located in the mine.

The Thornthwaite Lode (believed to be a northerly continuation of the Barrow-Yewthwaite Vein) (p. 26) lies immediately west of the main road on the S.W. side of Bassenthwaite Lake. It inclines eastward at about 24° from the vertical (2½ ft. per fm.). The hanging-wall is usually well defined and is frequently covered with 'douk'—soft blue clayey matter—from 0 to 10 ft. in thickness. The foot-wall is ill-defined or absent, mineral matter

[1] To whom our thanks are due for courtesy and assistance.
[2] 'Mines and Mining in the Lake District,' ed. 3, 1913, p. 91.

usually dying out in this direction as the ' foot-country ' flattens. The vein-filling is mainly smashed rock similar to the ' country,' with, as a rule, but little quartz. This renders the vein troublesome to follow and locate when barren.

Owing to the peculiar nature of the vein, it is difficult to estimate its average breadth. In the 65 and 85-fm. levels, south of the shaft, the space between the hanging-wall and the western limit of ore-bearing ground may be as much as 50 ft., and is frequently 20 to 30 ft. across. At such ' swells ' the hanging-wall, instead of hading to the east, inclines westward, and the stoping-ground is in two portions, with a barren tract in the middle of the vein.

The vein is stated to have been very ' gossany ' near the top.

The chief gangue mineral is quartz : it occurs in irregular strings and forms but a small percentage of the vein-filling, though occasionally (as in a stope above the 85-fm. level, north of the shaft) it is locally abundant and makes up the bulk of the vein. Dolomite, mixed with some pyrites, and forming cavernous masses, is met with in the 85-fm. level south. It is spoken of as ' burnt-up ground,' from its rough clinker-like appearance, but does not seem to be associated with barrenness in the vein as a whole, though some of the pyrites may be pseudomorphous after galena. Pyrites, nowhere abundant, is not restricted to any portion of the vein, although it may be a little more common in the deeper parts of the mine.

The ores obtained are of lead and zinc in the proportion of 1 to 2. Galena is the only lead-ore now raised, but cerussite is said to have been fairly abundant in the upper levels. The silver content, averaging about 10 ozs. of silver per ton of pig-lead, shows a slight increase with depth ; thus prior to 1915, it was a little above 10 ozs., while in 1918, the average was 10·97 ozs. per ton (by fire assay in both cases). Galena as a rule occurs in ribs, especially towards the hanging-wall : small bunches are occasionally found in the ' douk.' Towards the foot-wall these ribs are rare, thin and irregular, small splashes being commoner. Most of the blende, on the contrary, is found towards the foot-wall, and not in ribs, but scattered through the ' veinstuff.' There was an exception to this rule in a stope midway along the 85-fm. level south of the shaft, where the hanging-side showed a rib of blende about 4 in. thick and some yards in length, between two thin bands of quartz, followed by two ribs of galena about 6 in. in thickness. These ribs of ore are not constant in relation to the hanging-wall, but swing across the vein in an irregular manner.[1]

Little is known about the Rachel Vein, which, unlike the others, hades to the west, where it was originally worked along the outcrop on the steep slopes of Rachel Wood.

[1] J. D. Kendall maintains that ribs of ore are always parallel to the walls. ' The Mineral Veins of the Lake District ' *Trans. Manch. Geol. Soc.*, vol. xvii, 1884, p. 309. *See also* Force Crag, p. 22.

In the bottom of the wood, behind Walkergate, a cross-cut was begun some years ago, which after passing a barren vein, struck the Francis and Rachel Lodes, 10 to 20 yds. apart, about 180 yds. in. Ore was got from both veins over a length of 45 fms., the Rachel Vein being the better of the two. Continuations of the levels at both ends proved fruitless; on the north, though feeble slips may occur, this barrenness seems to be due to the vein dying out. Southwards, heavy broken ground was encountered, which suggests faulting, but the vein has not yet been picked up.

The cross-cut was continued westward without proving ore in bulk. Some thin quartz strings and a feeder of ferruginous water at 247 yds. from the entrance may represent the East Ladstock Lode. At the far end (about 474 yds. from the entrance) broken ground, 40 ft. wide and requiring heavy timber, was cut through. Some of the 'rushed-stuff,' of clay and slaty material, shows a small quantity of blende and galena and may therefore represent the West Ladstock Lode in a shattered condition. At the present time development is suspended at this point.

The East and West Ladstock Veins, referred to above, lie at the south end of the mining-field, and west of the Rachel Lode. They were exploited on a small scale at the old Ladstock Mine near the wood of the same name, and on the south side of Comb Beck. At the beck, these veins are about 100 yds. apart, but are believed to unite about 150 yds. farther south. Northwards they cannot be traced at the surface through the west side of Rachel Wood, but as already pointed out, may be represented in the Rachel Wood cross-cut. By Comb Beck there are open stopes with levels on the two lodes from which the veins seem to have been from 2 to 4 ft. wide, with a slight hade to the east. On the hill is an old shaft now filled up. The dumps are small, consisting mainly of Skiddaw Slate with a little quartz and blende. Galena was the ore raised.

The old Beckstone Mine, abandoned about 1830, lies north of Thornthwaite. A little galena was got here, from a vein which may be a northerly continuation of the Rachel Lode: the hade is not known, nor have we much information of any kind as to the workings. A cross-cut adit opening between 'Beckstones' and the high road (marked as a 'well' on the 6-in. map) is still partly open, but a day-level below the 'Bishop' rock, apparently on the vein, is blocked up at the entrance; several bell-pits and shafts may be seen on the south side of the stream.

Mining.

The proved ground on Thornthwaite Vein is about 320 yds. long, a shaft being sunk about midway, and levels driven off north and south along the vein at depths of 17, 27, 37, 47, 65 and 85 fms.

The present limits of the ore-bearing ground are somewhat peculiar. The 85-fm. level south ends against a blank wall with stringers of galena along it to the *west*. This was cut through and followed west for some yards, but the driving failed to locate the vein. The 65-fm. level south encountered a similar wall, an examination of which showed the usual contorted alternation of 'stony' and slaty bands, but none of the broken ground usually associated with faulting, though small slips may have occurred between sandstones and slates. In the 47-fm. level south, the vein was also lost, but the level was continued southwards with short cross-cuts at intervals. To the *east*, some of these penetrate the 'soft blue' or 'douk' on a smooth face similar to that of the hanging-wall. At the extreme south of the level (Sept. 12, 1919) thin quartz strings were encountered, and though no galena was seen the vein appears to be re-forming.

Once lost, Thornthwaite is certainly not an easy vein to find again, but in other respects presents no special mining difficulties.

The ore is raised at the shaft to about 16 ft. above the surface, and tipped to an incline for rough picking, before passing to two Marsden stone-breakers and a set of crushing-rolls. The material is then sized by trommel and elevated to the jigs (8 sets of jigs are in use, 2 being reserved for cleaning-up fine blende). The rejects from the jigs pass to a ball-mill. The fines are treated on tables (3 Diesters and 5 Wilfleys) and the slimes on a Luhrig Vanner.

The effluent from the dressing-floors passes into Bassenthwaite Lake. To prevent contamination an efficient and nearly automatic pair of large slime-settling pits, covering 2 acres or more, have been designed and laid down by Mr. A. Wilson on the gently sloping fields between the mine and the railway. They consist of a double wall (made of turf and tailings) with pipes at intervals leading through the inner wall at the lower end into the central enclosed settling-area. The coarser material is deposited in the channel between the double walls, and is partially removed at intervals to raise the walls and embankments. The finer material passes through the pipes into the central settling-area and gradually builds up deltas, and as these grow and extend, the pipes are inserted at higher levels in the growing walls. The effluent from the settlers is taken at the higher side of the pits and conducted to the lake. The deltas form natural buddles and show any ore leakage, however small, from the dressing-plant.

There is a steam winding plant, but water-power is used for pumping and is aided by suction-gas engines for driving the crushing and dressing plant as well as the air compressor for the seven rock drills in use in the mine.

Although the railway passes within 300 yds. of the mine, material has to be carted to Braithwaite station, a distance of 1½ miles.

From about 1870 up to the end of 1918 the total output of blende was 15,682 tons, valued at £90,673, and of galena 10,987 tons, valued at £111,515; the average price of galena during that period being £10 3*s.*, and of blende £5 15*s.* 5*d.* per ton. The proportion of galena to blende has decreased of late years; for the whole period 1870–1918 galena formed 41·2 per cent. of the total output, while in the years from 1870 to 1900 it was 51 per cent.

In 1918, by fire assay, galena averaged 81·36 per cent. of lead, and blende 49·7 per cent. of zinc. During 1919 the zinc in the blende has risen to above 50 per cent. Galena is usually dressed to an 81 per cent. concentration.

The recent yearly output is shown in Plate I, the maximum yearly production of galena being 890 tons in 1911, and of blende 1,099 tons in 1905.

Threlkeld Mine.

Threlkeld Lead Mines, Ltd., Thornthwaite, Keswick.

Situated half-a-mile N.N.E. of Threlkeld Village.

Maps.—One-inch New Series Ordnance, 29; Old Series Geological, 101 S.E.; 6-in. Geological, Cumb. 56 S.E.

History.

The two veins at Threlkeld have been worked as separate undertakings. Gategill is believed to have been wrought in pre-gunpowder days. Woodend is somewhat younger. It was reopened between 70 or 80 years ago by Messrs. Walton and Cowper, and continued working on a small scale until 1863. After an interval of 13 years, Gategill and Woodend were taken up by the 'Saddleback Mining Co.,' and some galena raised—chiefly from Gategill. Three years later the holdings were transferred to the 'Threlkeld Mining Co.,' which really developed the undertaking. The company went into liquidation in 1913 owing to the ore in depth proving to occur in short 'sops' separated by much barren ground. It has recently been taken up by Threlkeld Mines, Ltd., under the direction of Mr. Anthony Wilson.

Geology.

In the southern portion of the field there are two veins, about 200 yds. apart, ranging N.N.W. and S.S.E., which were worked independently in the past—the south-western vein and mine being known as Woodend and the one to the north-east as Gategill. When the workings on the Woodend Vein had been pushed farther north it was found that the vein had gradually swung round to about 10° E. of N., while the Gategill Vein had retained its original direction and at the intersection of the two was displaced about 20 fms. Unfortunately, detailed plans and reliable cross-sections are not available, but, according

to information given personally by Mr. J. Postlethwaite, the intersection takes place above and just beyond the 'new shaft,' situated about 370 fms. along the Woodend Horse Level.

The mining ground at Threlkeld rises by a series of steep slopes and crags from 700 ft., at the mouth of the mine, to 2,800 ft. on Hallsfell Top (the western end of Saddleback) in a distance of about 1 mile. The country—Skiddaw Slates—is traversed by numerous quartz strings, and as the veins make practically no show at the surface it is impossible to trace them without trial excavations. A group of narrow 'greenstone' dykes crops out in Gategill, but causes no marked alteration in the shales beyond a slight hardening. According to J. Postlethwaite[1] a mass of igneous rock, hading northwards at 5 ft. per fm., was cut through in the Woodend High Level (Smithy Level). It there measured 40 fms. in width, while in the deeper levels it was somewhat thinner and divided by 10 fms. of Skiddaw Slate. The veins were highly productive when in contact with the igneous rock. Unfortunately, no record of these occurrences has been kept at the mine. The present underground manager, Mr. Hewitson, states that some time ago a 'hard speckled rock,' 2 ft. in thickness and inclined from the vertical, crossed the vein in one of the stopes. This may be another 'greenstone.' He doubts whether the lode was affected, but states that blende continued up to the mass on one side but not beyond. Some chiastolite slate has been met with in the workings, but here, again, the exact location and effect upon the lode is doubtful. The Woodend Vein, contrary to the general rule, hades westward at from 40° or 30° from the vertical to nearly perpendicular, though the average is about 20°. The mean breadth of the vein may be taken as 4 or 5 ft., some stopes attaining 9 and 10 ft. in width while others are less than 3 ft. The hanging-wall, though usually well defined, is apt to prove a false guide in the 'nips,' or in barren ground, and leads off to the west, especially when, as frequently happens, stringers are given off on this side. The foot-wall is usually better defined and safer to follow.

The vein contains much country rock, especially when poor, but when the lode is rich there is usually a considerable amount of quartz (one-third to one-half the vein) in the form of soft sugary sand. In the deeper parts of the mine, now abandoned, pyrites was somewhat abundant and a Varpart disintegrator was in use to separate it from the other ores. That occurring above the Horse Level is usually in a fine state of division; it is found mostly in the 'deads,' and causes trouble, not so much in the dressing as by rotting the iron ventilation pipes, &c. Except in the case of one of the stringers barytes does not occur in this mine. Galena occurs in strings and ribs generally from 2 to 6 ins., though occasionally 1 ft., in thickness. Blende, often found in strings, is usually more irregular, occurring in scattered bunches and 'splotches' or disseminated through the gangue; the

[1] 'Mines and Mining in the Lake District,' ed. 3, 1913, p. 98.

average proportion in the present workings is about one of blende to three of galena, although in some stopes blende is predominant. Occasionally both ores occur in a fine state of division in sugary quartz; blende is then irrecoverable and floats off in dressing. There is a little copper-pyrites of no commercial value. The silver content of the pig-lead is generally about 8 ozs. to the ton.

The ore-bodies slope downwards to the north and are richest where the vein is wide and crossed by quartz strings. In depth—below the Horse Level down to 30 fms.—the ore-bodies were small (5 or 10 fms. in length, separated by 100 fms. of barren ground) and pyrites gave trouble. When the mine came into the hands of the liquidator the northern limit of the stoping-ground was regarded as a fault, but finding some indication of a foot-wall, the present holders continued driving and discovered a considerable ore-body at a point about a mile along the Horse Level. Here the galena and blende occurs in broad irregular bands, up to 1 ft. or 18 ins. thick, in soft sugary quartz interlacing the 'deads.' A trial stope, 60 ft. above the Horse Level, looks promising, and it is said that the ore-body is improving in height.

Branches are given off in places from the Woodend Vein. One of these is visible about 1,000 yds. along the Horse Level on the hanging-side. It was stoped to a small extent. About half a mile along the Horse Level, near the site of the electric-hoist, a short cross-cut east was made to endeavour to locate the Gategill Vein. A small vein was cut, believed to be a stringer from the Woodend Lode; it carried barytes and little 'sops' of blende but was poor in galena. The barytes is of good quality, white and practically free from metallic ores, but is not in sufficient quantity to work.

Little information is available concerning Gategill Vein, which is reported to have been mainly a galena vein with but little blende. The hade is said to be similar to that of Woodend, but where seen in Gategill is slightly east of vertical. The point of intersection with the Woodend Vein was the richest part of the mine.

Mining.

The main operations have been in the Woodend Vein, and the Horse Level, beginning at 700 ft. O.D., at the foot of Gategill, is driven along the somewhat winding course of the vein for about a mile. Half way along its course a 'blind shaft' led down to the 20 and 30 fm. levels, also reached by a shaft outside the main entrance. Both these shafts are now filled up. There are older levels farther up stream; of these, Smithy or Woodend High Level begins as a short cross-cut at about 820 ft. O.D. Higher up the ravine is the Woodend Top Level Cross-cut, commenced about 1870 and believed to be 160 fms. in length to the Woodend Vein. Close by, at 1,020 ft. O.D., is the Gategill Bottom Level, collapsed at the entrance,

where the lode, 3 ft. wide and with a western wall of 'greenstone,' is seen coursing N. 30° W. About 200 yds. farther N.N.W. is the site of the Top Gategill Level, which begins with a cross-cut of 10 fms. and is then driven 60 fms. on the lode (Gategill). The Middle Level is not visible; but both veins are said to have been wrought from it.[1] These levels extend almost as far north as the Horse Level and are probably all on the Woodend Vein in the hill, though the upper ones commence on the Gategill Vein to the south of the point of intersection. Haulage in the mine is by horses and mules along the Horse Level. Material is shot on to the picking-grates, where the block galena and the 'deads' are removed. The residue is raked into tubs below and tipped to the crushing-plant (a Blake Marsden stone-breaker and a set of crushing-rolls). After sizing, it is dealt with in five sets of four-compartment jigs and a Huntingdon mill grinds the rejects. The fines are treated on two modified Wilfleys and two Luhrig table-vanners. Two 'dollies' have replaced the buddles at one time in use here. The slime-treating plant is admittedly defective and is to be improved.

Settling areas similar to those of Thornthwaite are in process of construction.

Water for dressing comes from Gategill Beck, the plant being operated by a gas-engine.

Transport is by cart to Threlkeld Station (C.K. & P. Railway), a distance of a little over 1 mile.

As the newer part of the mine is only in the developmental stage, the output is at present small. In the past about 100 men and boys were employed, with an average yearly production of 550 tons of galena and 700 tons of blende.

The output of Woodend Mine in 1848 was 36 tons of dressed lead ore. For the next two years figures are not given. From 1851 to 1853 the figures are 13, 8½ and 30 tons respectively. After another interval, 58 tons was produced in 1862 and 23 in 1863. The output in subsequent years is shown in Plate I.

Greenside Mine.

Greenside Mining Co., Glenridding, Penrith.

Situated about 1½ miles west of the head of Ullswater.

Maps.—One-inch New Series Ordnance, 29; Old Series Geological, 101 S.E.; 6-in. Geological, Westmorland 12 N.W.

History.

This mine, after a period of intermittent work, has now been in continuous operation for over 100 years. The workings of the latter part of the 18th century are situated on a tableland at 1,850 ft. above O.D., and on Glencoindale Head (2,500 ft.

[1] *Ibid.*, p. 98.

above O.D.). Washing and dressing of the ore was then on a primitive scale and could be carried on only nine months in the year on account of frost and snow. The dressed ore was carried on pack-horse to Keswick or Stonycroft Gill for smelting.

The lowest level previous to 1825 was that now known as the High Level. Later a cross-cut, from Lucy Tongue Gill, cutting the vein 30 fms. deeper, was made (the Low Level), and from this a shaft was sunk on the vein. In 1851 the Lucy Tongue Level, driven to cut the vein 82 fms. below the Low Level, was commenced. In 1862 a vertical shaft was made from the Lucy Tongue Level with cross-cuts *east* to the vein. This, after successive deepenings, was abandoned, and in 1891 a new vertical shaft ('Smith's,' still in use) was commenced 75 fms. north of the old shaft and 22½ fms. east of the vein which it intersects at about 50 fms. below the Lucy Tongue Level. Since then work below the 90-fm. level has been carried on from an inclined shaft on the vein.

Geology.

The Greenside Lode runs approximately north and south for about ¾ mile and hades eastward at from 8° to 18° from the vertical, the vein being richer in the steeper portions. Several barren east and west cross-courses displace the lode, the most important being the North Cross-course, the Johnson Ross Back Vein and the Clay Vein. The North Cross-course traverses the richest part of the ore-bearing ground about Glencoindale Head, and on its northern side shifts the lode 60 ft. to the east (Fig. 2). The Johnson Ross and Clay Veins, about 50 yds. apart, lie at the south end of the mine. The Clay Vein, underlaying south, has a good hanging-wall and is composed of soft sandy clay, or flookan. It marks the southern limit of the mine, breaking up the Greenside Lode so much that the latter is unrecognisable farther south.

The 'country' is composed of lavas, tuffs and ashes of the Borrowdale Series, and according to Mr. W. H. Borlase,[1] who has long been connected with the mine, the nature and composition of the vein varies in sympathy with the country-rock. The chief ore-bearing sections are in hard massive tuffs. The non-productive parts are in less compact and softer tuffs and ashes, whilst the vein itself is reduced to small proportions and carries friable quartz with small quantities of iron-pyrites. The foot-wall is constant, but the hanging-wall is sometimes ill defined, owing to strings of ore penetrating the 'country.' It is usually better defined where the vein is 'nipped.' At the north end of the mine, along the contact with a quartz felsite dyke, the vein is quite 'dead.'[2]

---

[1] 'History and Description of the Greenside Silver-lead Mine, Patterdale,' *Trans. Fed. Inst. Min. Eng.*, vol. vii, 1894, p. 645.

[2] 'The Geology of the Northern Part of the English Lake District' (*Mem. Geol. Surv.*), 1876, p. 54.

The vein-filling is mostly a breccia of 'country rock,' the fragments here and there attaining a volume of 2 or 3 cubic ft. Quartz occurs locally, and for short distances may form one-tenth to one-fifth of the vein content. In the higher part of the mine, now abandoned, barytes of good colour was locally abundant, but was never worked. When barytes is present the vein generally expands to a great width, yielding in places 10 tons of argentiferous galena per fathom. Calcite is not common, though

Fig. 2.—Diagrammatic Sketch Plan of Greenside Mine to show Shifting of the Lode by East and West Faults.

occasional specimens of 'nail-head' spar may be obtained Galena is the only ore of commercial importance; there is some blende and a little iron-pyrites, but copper-pyrites is rarely seen. The galena may be in bunches or small patches, but the best ore occurs in ribs and strings, carrying $9\frac{1}{2}$ to $10\frac{1}{2}$ ozs. of silver per ton of pig lead. Where the vein is rich quartz is frequently, but not invariably, associated with the ore.

The breadth of the vein is variable. In the upper levels it was, in places, 50 ft. across, but, in depth (where the ore appears to be more concentrated), the average width of the stopes is about 8 ft. At one locality in the 90-fm. level, the vein swells out to 30 ft., while directly beneath, in the 105-fm. level, it splits into three parts. In some of the swells on the 105-fm. level, where the vein is 12 to 15 ft. wide, the hade of the hanging-wall is reversed.

In the pinched portions (as in places about the 90-fm. level) the vein averages only a foot and is barren. The ore makes its reappearance in the form of ' sops ' and small bunches, gradually increasing to stoping quantity and quality.

Strings of ore leave the lode at frequent intervals, and are sometimes spoken of as the ' feeders from the east.' Several of these have been followed, but have proved barren a short distance from the main lode, though they appear to enrich the latter at their junction. Some of the strings appear to be located in definite cross-courses, but in such cases, although easily followed, seldom yield ore. On approaching a cross-fault from the south the ore in usually good up to the slip, but when the vein is located on the north side it is generally of less value.

There are three main ore-bodies in the lode, all inclined northwards and extending over a total length of 260 fms.; they have now been proved to a depth of 120 fms. below the Lucy Tongue Level, or 1,600 ft. below the mean height of outcrop. They increase in length with depth, and as yet there appears to be no sign of deterioration; in fact, the north ore body, first discovered at outcrop, is said to be continuous and to have improved in depth. The south ore body, bounded by the Clay Vein, and similarly the smaller ' middle ' ore body, is said to be more erratic and to be either very rich or very poor.[1]

Mining.

In the workings, now abandoned, the Low Level, 82 fms. above the Lucy Tongue Level, was the most important; the connecting shaft is now used for transmitting power by electric cable. The Lucy Tongue Level, at 1,100 ft. above O.D., begins on the Lucy Tongue Vein (east of and parallel to the Greenside Lode) along which it was continued until the Clay Vein (Fig. 2) was cut; after following this westward for some distance the miners found themselves too far south of the ore-producing ground proved in the upper levels of the Greenside Vein; the direction was therefore again changed to N.W. and the level continued as a cross-cut until it met the main lode. The meandering adit thereby made is three quarters of a mile long and took 17 years to drive.

From the Lucy Tongue Level a vertical shaft was sunk to the 90-fm. level, from which an inclined ' skip shaft ' on the vein will shortly be completed to the 120-fm. level. From these

[1] W. H. Borlase, *Ibid.*, p. 647.

shafts levels are driven off north and south 15 fms. apart, and the vein worked out by means of headings or lifts from roof to sole, with the exception of arches or ' cranches.'

All material is conveyed by tram to the shafts. At the Lucy Tongue Level these are made into 12-wagon trains and drawn out by an electric locomotive.

The ore is tipped near the mouth of the adit, the ' deads ' picked out and the rest loaded into tubs and hauled up an incline to the dressing-floors—these having originally been built to serve the higher levels. After passing through a rock-breaker and three pairs of crushing rolls the material is then trommelled, the ' sizes ' passing to the jigs (five three-compartment and one four-compartment) which, owing to the rather coarse nature of the ore, give very clean ' chatts ' or ore-free residues. The rejects from the trommels go to two Huntingdon mills, and, after sizing, the coarse is jigged in five three-compartment jigs, the fines being treated on tables (four Record, two Luhrig, and four double-belt vanner tables). Slimes from the settling-pits are treated at intervals in buddles, of which eight are in use.

The galena is dressed to an 82½ per cent. concentration; until recently it was smelted at the mine and the lead desilverised, but these works (started between 1830–40) are now disused, as they cannot compete with modern smelters.

Greenside Mine is fortunate in having an abundant supply of water at high elevations; advantage has been taken of this to generate electricity for lighting and underground power, the mine being a pioneer in the North of England in this respect.

Red Tarn and Kepple Cove Tarn on the flanks of Helvellyn are utilised as reservoirs, and the power-station (Gilke's turbine dynamo) is situated at the base of Catchedecam. The water is taken at 1,750 ft. above O.D., and flowing through leats and pipes gives a fall at the generating station equivalent to a vertical head of 400 ft., with an effective horse-power of about 200. The current, at 2,000 volts, is conveyed through old workings to the Lucy Tongue Level, where it is transformed to 600 volts for hoists and pumps and 250 volts for the electric locomotive.

The waste water from the power-station is used for the dressing-plant, which it also drives by means of water-turbines, subsequently going to a large water-wheel just below the mine buildings; this works the compressor for the six rock-drills and drives the saw-mill, &c.

Transport is by road to Troutbeck Station (C.K. & P. Ry.), a distance of about 9 miles.

Previous to 1876, the total output is recorded[1] as 60,000 tons of lead ore, yielding, with the smelting plant of those days, 40,000 tons of lead worth about £800,000, and 600,000 ozs. of silver worth £150,000.

The yearly output of dressed lead ore from 1848 onwards is shown by the curve Plate I, the figures for 1912–18 being

[1] J. H. Murchison, ' British Lead Mines,' London, 1876, p. 21.

furnished direct by the company. The metallic lead content of the dressed ore (by dry assay) rose from 73 per cent. in the period 1885–91 to 81 per cent. in 1895–1905, and 82 per cent. onwards.

Brundholme Mine (with Blencathra).

Brundholme and Newlands Mines, Keswick.

Situated in Glenderaterra Valley, a little south of Roughten Gill.[1]

Maps.—One-inch New Series Ordnance, 29; Old Series Geological, 101 S.E.; 6-in. Cumberland 56 S.E.

History.[2]

The earliest mining—done about 1820—was near Roughten Gill. Levels were driven northwards on two veins. A shaft was sunk below adit-level, but the workings were abandoned.

About 1850 a shaft was sunk to a depth of 20 or 25 fms. on the eastern side of the stream, about ½ mile south of Roughten Gill, but lack of capital led to the mine (known as 'Blencathra') being abandoned, though some good ore was obtained. The vein lies 12 fms. east of the shaft. Some distance to the north it is said[3] to become 'broken.' To the south it has not been proved. Short levels have been driven lower down the valley to attempt to cut the western vein, but were abandoned before doing so.

In 1872 work was recommenced about 300 yds. south of Roughten Gill, and a shaft sunk to 30 fms., with levels north and south at 20 and 30 fms. from the surface, but the mine was soon closed again.

After an interval of many years the mine was reopened; the levels begun in 1872 were pushed out, chiefly to the south, and a run of ore was found about 40 fms. south of the shaft. A rise has been worked up in this part of the mine from the 30-fm. level through and above the 20-fm. level. The mine was again abandoned some years ago, though periodic trials have been made. Recently it has been reopened by the Brundholme Co., first under the management of Mr. B. Johns, and lately under Mr. Borlase.

Geology and Mining.

There are two main veins here, one running a little east-of-north from the foot of Lonscale Crags to Roughten Gill (where it splits into strings), and the other a little west-of-north and coursing southwards from Sinen Gill. These two intersect about 100 yds. south of the junction of Roughten Gill with the

[1] Not the Roughton Gill of Caldbeck Fells.

[2] From 'Mines and Mining in the Lake District,' by J. Postlethwaite, ed. 3, 1913, pp. 101–103.

[3] 'Northern Part of the English Lake District' (*Mem. Geol. Surv.*), 1876, p. 52.

main stream; and to the south, near the old Blencathra Mine (where they are about 120 yds. apart), are united by a small cross-vein bearing E.N.E. and W.S.W.

These veins traverse Skiddaw Slates, in the aureole around the Skiddaw Granite, into unaltered strata on the south.

The veins are filled with rock fragments and quartz, and variable amounts of barytes, galena and copper-pyrites with some cerussite ($Pb.CO_3$), malachite ($CuCO_3.Cu(OH)_2$) and chrysocolla ($CuSiO_3 + 2H_2O$).

The northern parts of the veins, between Sinen and Roughten Gills, are said to have yielded mainly copper-pyrites, but farther south, galena prevails, accompanied by barytes: the latter mineral is white and apparently of good quality. The small amount of copper found on the south usually appears in patches in the middle of the vein, surrounded by galena and barytes.

It is said that the ore-bodies frequently appeared rich and promising, but, on further investigation, have proved disappointingly small; in addition, the lodes are low-lying and require shafts with pumping and haulage machinery, so that operations are costly and, as a rule, of short duration.

The Brundholme Company have recently sunk a new shaft to 35 fms. and raised a little barytes and lead-ore, but work is still largely in the stage of development. Pumping by water-wheel is carried out from the northern shaft. Ore is raised in kibbles by a small steam-engine.

A rather rough mountain road leads to Threlkeld Station, a distance of about 3 miles.

Force Crag Mine.

Braithwaite Mines Ltd., Force Crag, Braithwaite, Keswick.

Situated at the head of Coledale, $2\frac{1}{2}$ miles south-west of Braithwaite village.

Maps.—One-inch New Series Ordnance, 29; Old Series Geological, 101 S.E.; 6-in. Geological Cumb. 63 S.E.

History.[1]

This mine has a somewhat chequered history partly attributable to the difficulties in the past of separating blende from barytes, and the predominance of those two minerals over the more readily dressed lead-ore.

About the year 1830, the mine was opened, or probably reopened, by Mr. Walton, of Alston, Messrs. Dowthwaite and Cowper of Keswick, and others, who drove Nos. 1, 2 and 3 levels. A considerable amount of ground was excavated, especially in the old stope, where the most productive ore-body lay. As barytes was unsaleable in those days, little attention was paid to it.

[1] *See* 'Mines and Mining in the Lake District,' ed. 3, 1913, p. 103.

After a short interval, the mine was reopened for barytes, and as that mineral was found to be more plentiful on the higher ground the lower levels were abandoned and the Nos. 4 and 5 levels commenced.

A tramway was constructed to the village and mills erected, but the undertaking proved unremunerative and the mine was abandoned in 1880.

In 1906 the mine was taken up for lead- and zinc-ores by Messrs. Dennison, Meakin and Lobb, who reopened the lower levels and installed the Pelton wheel and dressing-plant. Owing to the difficulties of dressing blende and barytes the mine was abandoned in 1909. The Coledale Mining Syndicate began in 1912, and lasted until 1915. They were responsible for the erection of the Elmore plant, but were hampered by inadequate crushing machinery. The present company was formed about the year 1916.

Geology.

The Force Crag Vein is believed to extend from the head of Coledale westward to the foot of Crummock Water, a distance of nearly three miles; but with the exception of a small trial near Lanthwaite Gate, at the western end, it has been worked only at Force Crag. A parallel vein (Long Crag) crops out some 200 yds. north of Force Crag Vein, but has not been worked, and there is little or no information concerning it.

The Force Crag Vein courses a little N. of E. and S. of W. through the Skiddaw Slate Series, and generally hades northward at 75° from the horizontal, though at times it is practically vertical.

The vein-filling, apart from minerals of economic importance (blende, galena and barytes), consists mainly of brecciated rock, with thin irregular strings of quartz. Of the other minerals, psilomelane occurs in the higher part of the vein, and a little dolomite is of general distribution, along with some chalybite and pyrites. Cerussite and stolzite (tungstate of lead) are also reported, and during this visit, a few small crystals of pale greenish fluorspar were obtained for the first time.

The order of introduction of the minerals is not always obvious, as quartz has been introduced into the vein at several times, but with this exception the general rule appears to be :— an initial deposition of quartz, followed in turn by galena, blende, barytes-dolomite, and psilomelane-pyrites. The paired minerals appear to be interchangeable.

The proportion of barytes to ores is about 3 : 1, and, of the ores, blende is about 10 times as common as galena. The average silver content of the lead is about 30 ozs., though sometimes it is as high as 35 ozs., per ton.

The width of the vein, which varies from 1 to 20 ft., probably averages 5 ft., and the walls are usually well defined. In places, as in the middle portion of No. 1 level, the lode splits into two veins, from 2 to 4 ft. wide, separated by a barren tract or ' horse '

12 to 15 ft. across. Small branches or veinlets are given off at different points. These usually carry ore near the vein only.

On the top of the mountain the vein consists mainly of barytes with psilomelane, lead and zinc being practically absent. In depth, blende with some galena becomes more abundant, in No. 3 level, and the stopes above it, for example, where they form the chief ores, the barytes here occurring in small patches on the walls and occasionally running irregularly through the vein. In No. 1 level—the lowest worked—barytes comes on again. In a stope just east of the cross-cut to the level the vein is 15–20 ft. wide and has lenses of good white barytes on the walls, 2 to 3 yds. long and 6 to 8 ins. thick, in addition to ribs in the middle of the vein. Where the ' horse ' appears the veins carry in places 6 ins. to 3 ft. of solid barytes. Blende, though sometimes in ribs and in bunches, is more often somewhat scattered. Galena is usually in bunches, is frequently scattered, and but seldom occurs in solid ribs. The lead and zinc ores are usually in bands running diagonally[1] through the veinstuff from N.E. to S.W. Sometimes these runs of ore appear to be in conjunction with ' slips,' but this is not always the case.

Mining.

The vein has been opened up by a system of levels, the highest (No. 5) being about 400 ft. above No. 1. Extensive screes on the lower slopes of the hill have necessitated the use of cross-cuts, driven from the south, from which the three bottom levels (Nos. 1, 2 and 3) proceed. No. 1 cross-cut is about 120 yds. long, the others one-half and one-third that distance. No. 3 level is 15 fms. above No. 2, and the latter 24 fms. above No. 1. Nos. 4 and 5 levels, opened directly on the vein, are now disused, but may be reopened for the purpose of winning barytes. No. 1 level has been driven west about 180 fms., but the vein there is said to be disturbed and may be faulted. From No. 1 level two cross-cuts have been driven northwards towards Long Crag Vein (believed to crop out about 200 yds. north of the Force Crag Lode), but were abandoned before attaining half the distance. A cross-cut, commenced some years ago with the object of cutting the Force Crag Vein 120 ft. below No. 1 level, has not been completed, and mining is confined to the ground between No. 1 and No. 3 levels. No. 1 level and cross-cut form the main drain of the mine, and no pumps are required.

Up to the present, mining has been done by hand labour, but a compressor has been installed recently and rock-drills will be used in future.

Some of the lump barytes is picked out in the mine, whilst the rest of the material is trammed from No. 1 level to the picking-grate above a Marsden stone-breaker. After breaking, the

[1] *See* footnote, p. 8.

ore is first subjected to the ordinary processes of classifying and jigging.

The rejects from the jigs are ground in a stone-ball mill and are then ready for the four Diester tables, two of which are for 'sands' and two for 'fines.' The mixture of blende and barytes from the tables is treated by the Elmore oil-vitriol-vacuum process, which gives practically pure blende. The gangue from the Elmore process is then cleaned up on a long Buss table and yields a medium-grade barytes sand.

Power is supplied by a Pelton wheel using water from a reservoir at the head of the beck, 600 ft. above the level of the mine buildings.

Transport is by cart to Braithwaite Station (C.K. & P. Ry.), a distance of 3 miles by a well-graded road. Some years ago, a tramway was constructed, but the metals were subsequently removed.

The output of dressed lead-ore for 1848–49–50 was 43, 27 and 8 tons respectively. From 1857 to 1863 a total of 295½ tons was produced, whilst, in 1872, 600 tons of blende was sold. Ten tons of dressed blende was sold in 1908; and 9 tons of galena, 140 tons of blende, and 35 tons of barytes in 1909. In 1913, galena amounting to 32 tons was obtained.

Goldscope or Newlands.

(*Prospecting.*)

Brundholme and Newland Mines, Keswick.

Situated about a mile south of Little Town in the Vale of Newlands. Mine buildings on west side of the beck.

Maps.—One-inch New Series Ordnance, 29; Old Series Geological, 101 S.E.; 6-in. Geological, Cumb. 69 N.E. and 70 N.W.

History.

Goldscope Mine has had a long and varied career,[1] being worked at first in the Middle Ages for copper ore.[2] About the year 1850, the owners (Messrs. Clarke & Co.) were extending the adit in search of further supplies, when they struck the 'Great Lead Bunch' of the Goldscope Lead Vein. When first met with the richest part of this ore-body was 15 fms. long, with one rib of solid galena 3 ft. wide in addition to smaller ribs from 3 to 8 ins. in width. The ore-body became less rich in depth, but extended in length to 45 fms. About the year 1866, when most of it had been extracted, the mine was abandoned and has remained closed until recently.

[1] The history and much information relating to this mine is given in 'Mines and Mining in the Lake District,' by J. Postlethwaite, ed. 3, 1913, pp. 76–81.

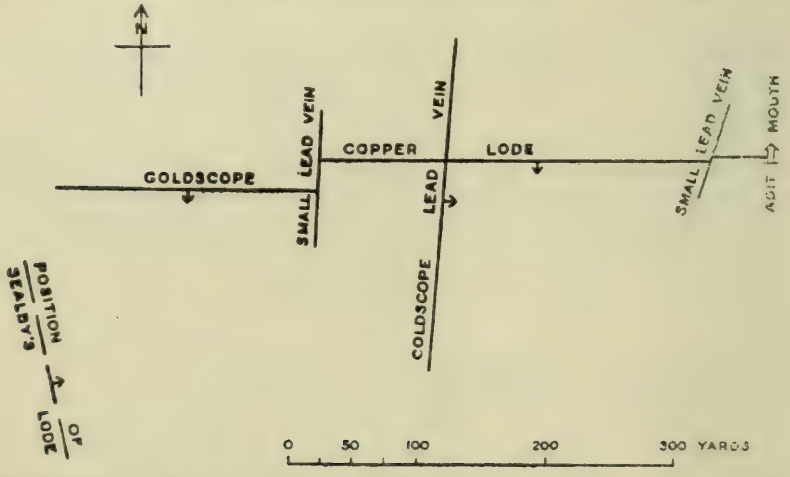
[2] The copper ores of England and Wales are to be described in a special memoir of this series.

Geology.

At Goldscope, a number of ' lead ' veins, ranging from N. to S. and N.N.E to S.S.W., intersect and frequently displace an E. to W. copper lode. The most important are ' Sealby's Lode ' and the ' Goldscope Lead Vein,' which cross the western side of Scope End.

The Goldscope Lead Vein (Fig. 3) hading easterly at 1 ft. to 18 ins. per fm. from the vertical, crosses, but does not displace,

FIG. 3.—DIAGRAMMATIC SKETCH PLAN OF GOLDSCOPE MINE ALONG THE ADIT, SHOWING SHIFTING OF EAST AND WEST COPPER-LODE BY NORTH AND SOUTH LEAD-VEINS.



the ' copper ' lode at a distance of 250 yds. from the entrance to the adit along the latter vein. The lead vein is poor and contracted at the surface, but improves in depth for some distance. The average width above the adit is about 5 ft., though in places it increases to as much as 12 ft., while below the adit it does not average more than 3 or 4 ft. Beyond the 80-fm. level the vein becomes somewhat confused, and in places, particularly west of the shaft, carries soft sandy quartz 12 ft. in width. In the lowest workings, the vein is in parts 32 ft. in breadth, but here includes several ' horses ' of barren material.[1]

The only definite off-shoot from the lode is the ' Borrowdale String,' which splits off to the west at about adit-level and rejoins the main vein about 80 fms. deeper.

The intersection of the copper and lead vein was the richest part of the mine and was known as the ' Great Lead Bunch,' but away from the junction the lode does not carry much ore. The length of this rich ore-body proved to be short—from 15 to 45 fms.—extending to a depth of 90 fms. below the adit, but becoming poorer and not worth working below that level. When this ore-body was exhausted and explorations to the north and

[1] J. D. Kendall, ' The Mineral Veins of the Lake District,' *Trans. Manch. Geol. Soc.*, vol. xvii, p. 305.

south had failed to locate other workable bodies—though patches of galena were met with—the mining of this vein was abandoned.

The vein-filling consists of variable amounts of quartz, sometimes 3 or 4 ft. wide, and smashed country rock (Skiddaw Slates), with, in places, a considerable amount of blue clayey ground or 'douk.' There is a little blende, but galena is the only ore of economic importance. The silver content is low—generally 7 or 8 ozs. per ton of pig-lead. Galena occurs chiefly on the foot-wall side in solid ribs and bunches; one mass from the richest part is said to have contained 50 cubic yds. of solid galena.[1]

Where the vein contains 'douk' galena is found in blocks or bunches in the clay. At the south end of the mine the 'Borrowdale String,' in the 60-fm. level, contained flat 'beds' of galena about 9 in. thick, which were easily lifted by crowbars from a soft matrix of quartz.

At the present time (Autumn of 1919) a certain amount of galena is being obtained from ground 'rushing in' from what is believed to be a string from the Goldscope Lead Vein, not far from the top of the old shaft. It is not easy to maintain the workings, which are in treacherous collapsible ground. The galena here occurs in blocks up to a cubic foot in volume and receives no dressing beyond cobbing.

Sealby's Lode, hading parallel to the Goldscope Lead Vein and west of it has never been properly opened out, but the adit on the copper vein is now being pushed forward in the hope of intersecting a rich ore-body at the junction.

The Sealby Lode, though sometimes 6 or 7 ft. wide, is said to be smaller than the Goldscope Lead Vein and to contain more sandy quartz. Galena generally occurs as blocks, balls, and bunches in this soft matrix. The lode was worked at the surface to a limited extent, south of the line of the 'copper' adit and from 20 to 60 fms. west of the Goldscope Lead Vein: apparently it swings away northwards, as at the time of examination (22nd September, 1919) the adit was already 305 yds. beyond the latter vein and had not then intersected Sealby's Lode.

In the adit, 95 yds. west of the Goldscope Lead Vein, the copper lode is shifted 24 yds. to the south by an unnamed 'lead' vein; the latter runs approximately N. and S. and is almost vertical; it has been stoped out for a short distance above the adit, where it was 3 to 4 ft. in thickness.

Farther east, about 44 yds. from the entrance to the adit, the copper-lode is shifted a few feet southwards by another 'lead' vein, too small to be worth working.

Mining.

The Goldscope Vein, below the adit, was worked by means of a shaft with levels at intervals of 10 fms. Water for driving the wheel used for hoisting, &c., fixed at the top of the shaft

[1] J. D. Kendall, *ibid.*, p. 310.

in the adit, was carried into the mine by a leat from Scope Beck in Little Dale, and through a small back-level on the vein. A cross-cut north of the copper-lode, commenced by Mr. Plummer, was never completed.

The output, year by year, of dressed lead-ore from 1851 to 1863 was 14, 18¼, 266, 365, 456, 422, 351, 535, 391, 415, 480, 480 and 350 tons. The output for 1864 is included with that of Yewthwaite and made 250 tons. In 1865 and 1866 respectively, 150 and 35½ tons were raised.

SECTION 2.—ABANDONED MINES AND TRIALS.

A. Keswick Field.

Barrow Mine.

(*Abandoned.*)

Situated on the west side of the Vale of Newlands, near Uzzicar, ¼ mile N.N.W. of Stair.

Maps.—One-inch New Series Ordnance, 29; Old Series Geological, 101 S.E.; 6-in. Geological, Cumb. 64 S.W. and N.W.

History.[1]

Little is known of workings previous to 1848 except that mining was on a small scale. From 1848 to 1865 the mine was held by the Keswick Mining Co., and in prosperous times, 12 to 16 tons of ore were raised per month. Later it was taken up by H. K. Spark, but produced little ore, although some exploring was done in the lower levels. Towards the end of 1883, the Barrow Mining Co. was formed under the direction H. B. Vercoe, and the 40-fm. shaft was sunk. The mine was finally abandoned about 1890, after the death of Mr. Vercoe.

Geology.

At Barrow Mine the Yewthwaite Lode (p. 28) splits into at least two parallel branches[2] known as the Barrow Lode and the Sandy Vein; these are said to be 15 fms. apart in the upper level and 20 fms. at the lower level—the Sandy Vein lying west of the Barrow Lode. The hade in each case is easterly, though the Sandy Vein is almost perpendicular. Both veins are filled with rock-debris and quartz in varying proportions. In some places the latter is in hard bands; in others, particularly in the Sandy Vein, it is very friable and free-running causing great trouble and blocking the workings. The only other gangue mineral noticed is a little pinkish calcite. The ores are in

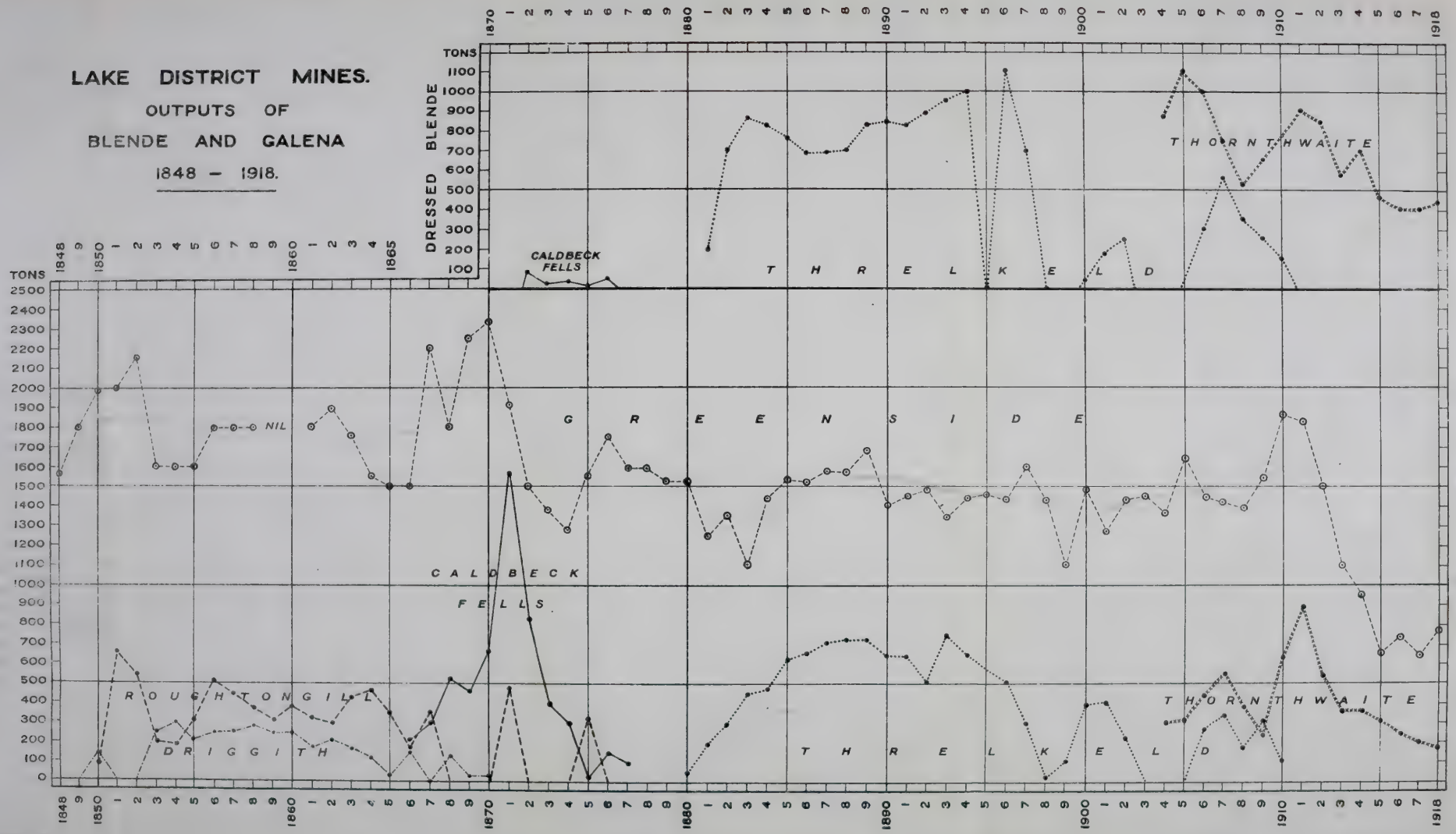
[1] J. Postlethwaite, 'Mines and Mining in the Lake District,' ed. 3, 1913, pp. 88–90.

[2] Three lines of shallow pits, which may be traced at the base of the hill, suggest the existence of three branches, but only two are known in the workings within the hill; as there are no plans, this matter cannot be settled definitely.

LAKE DISTRICT MINES.

OUTPUTS OF BLENDE AND GALENA

1848 – 1918.



(295.59.968.750.

C&R LTD. 414.

ribs and lumps, chiefly of galena, though some blende has been obtained, in addition to minor quantities of cerussite, pyromorphite, and pyrite.

It is reported that certain portions of the veins were very rich, but the veins are said to have become poor and disturbed against a mass of contorted shale when the workings had got 'well into the hill.' According to other reports the ending is a blank wall. This suggests a fault, but the ground on the far side has never been explored.

Mining.

Initially several levels were driven in the hillside, some being still partly open. In 1884 a shaft was sunk near Uzzicar to a depth of 40 fms., from which three sets of levels were driven—at 18, 30 and 40 fms. respectively from the surface. The 18 and 30 fm. levels were each driven about 80 fms. northwards and 60 fms. southwards from the shaft, and are said to have discovered some good ore-bodies, especially on the north; the 40 fm. headings, however, were not extended beyond 8 fms. before the mine was abandoned.

The total length of ore-bearing ground proved here is about 500 yds., and this has been stoped out through a height of about 400 ft.

Superficial workings on the backs of the veins may be seen on the north side of Barrow Hill, but in the intervening ground between there and Thornthwaite the lode has not been worked, and is not traceable at the surface on account of Glacial drift and hill-wash.

The production during the $5\frac{1}{2}$ years under the last company is stated by Mr. Postlethwaite to have been 240 tons.

Stonycroft Mine.

(*Abandoned.*)

Situated in Stonycroft Gill, near Stair in the Vale of Newlands.

Maps.—One-inch New Series Ordnance, 29; Old Series Geological, 101 S.E.; 6-in. Geological, Cumb. 64 S.W.

History.[1]

The 'old men' located the vein along the course of the Gill, and in order to win the ore diverted the stream above the waterfall by means of a dam. A shaft was then sunk, about 7 fms. in depth, close to where the vein enters the hill on the east; but owing to the bursting of the dam this was filled with debris. The Keswick Mining Co. reopened the mine in 1846, cleaned out and deepened the shaft to 17 fms., and drove levels east and west. Two water-wheels were erected for pumping and dressing, but the amount of ore raised was small, and the mine was abandoned between 1855 and 1860.

[1] J. Postlethwaite, *op. cit.*, pp. 90–91.

Geology and Mining.

The Stonycroft Lode may be a continuation of the western branch of the Brandlehow Lode (p. 31), and is believed to intersect the Barrow-Yewthwaite Vein (p. 26) along Newlands Beck. Coursing E.S.E. and W.N.W. through Skiddaw Slates it is seen in Stonycroft Gill immediately above the bridge, hading northward at 10° from the vertical, and about 4 ft. in width. The vein is filled with broken rock and quartz, and yielded galena. Towards the hanging-wall the quartz is in solid ribs with lumps and patches of galena 3 to 4 ins. in diameter : in depth much of the quartz is said to be friable.

The length of vein worked was probably about 300 yds., and the depth about 20 fms.

At the head of Barrow-Gill, ¾ mile N.W. of Stonycroft, there are some ancient workings on what is believed to be the Stonycroft Lode, but nothing has been done in the intervening ground, and the outcrop is obscured by screes and heather.

South of Stonycroft, on the flanks of Rowling End, there are several old trials for galena, but the amount of ore raised appears to have been small.

Yewthwaite Mine.

(*Abandoned.*)

Situated on the east side of the Vale of Newlands, ¼ of a mile E.S.E. of Little Town.

Maps.—One-inch New Series Ordnance, 23; Old Series Geological 101 S.E.; 6-in. Geological, Cumb. 64 S.W.

History.

According to Mr. J. Postlethwaite[1] the mine was probably opened in the latter part of the 18th century. The Low Adit was reopened by Messrs. Clarke and Co., in 1849. Some years later the Trustees' Level and the deeper workings were made by trustees of the Company. About 1870 the mine was sold to H. K. Spark, of Darlington, and transferred still later to H. B. Vercoe, but was worked with less vigour than formerly. It was abandoned during the late 'eighties,' though a little exploring was done in 1891 by the Derwentwater Copper Lead and Zinc Company.

Geology.

The lode at Yewthwaite ranges N.N.W. and S.S.E., and hades eastward at 20° to 30° from the vertical. It appears to follow the main jointing in the Skiddaw Slates, which here dip E.S.E. at from 45° to 60°.

The vein, when ore-bearing, has an average width of 2 ft., but it is sometimes 'nipped' to a mere barren string. It is filled with quartz—often soft and crumbly—in ribs up to 8 ins.

[1] *Op. cit.*, p. 86.

thick, mixed with brecciated rock. Galena and blende occur in ribs and nests, the former being the predominant ore, though blende is locally abundant in the upper part of the vein at the south end of the mine. Amongst the material near the outcrop a little cerussite and pyromorphite was noticed.

The vein has been worked out over a length of 200 fms., and to a depth of 30 fms. below the Trustee Level—*i.e.*, to a total depth of about 500 ft. below the hill outcrop. Down to 20 fms. below the Trustee Level the vein is said to have been fairly rich, but beyond that depth (according to Mr. R. Sanderson, of Keswick) although the vein frequently looked promising, the galena 'sops' proved to be of short length and separated by much barren ground. At the south end of the mine the lode becomes inferior, being largely filled with 'douk' and crossed by many slides. Due east of Little Town a copper-lode, probably that of Goldscope (p. 24), running north-eastward between Knott End and High Crags, is believed to intersect the Yewthwaite Lode, but though a short trial-level was driven a little to the south-west to test the copper-lode, apparently no attempt was made to prove the junction.

Mining.

The earlier mining on top of the hill is marked by short day-levels and shallow shafts, in which sections of the vein may still be seen. About 100 yds. north of the sheep-fold the vein was apparently stoped-out to daylight, and the surface has partly collapsed. The hade is flatter here than is usual at the crop. The foot-wall is covered with a 4-in. band of fine, hard, granular quartz, mixed with a small proportion of brecciated rock. The vein appears to nip out at the surface here, but to swell out to 4 or 5 ft. in width about 10 ft. below ground. Two old shafts, now filled up but still surrounded by rings of debris, lie 80 yds. north of the sheepfold. From the sheepfold for 75 yds. south along the vein old stopes and levels have caved in; these are reported locally to have been in good ground, carrying blende in addition to lead-ores. The highest workings are some 200 yds. south of the sheepfold, and just below the 1,250 contour at the top of Yewthwaite Comb. An old trial-level, still open, extends over 20 yds., and the vein-filling is quartz in thick ribs with smashed slate, over a width not exceeding 2 ft. The vein seems poor here; it carries some galena, but apparently no blende.

When the upper part of the lode was exhausted a cross-cut called the Low Adit (80 fms. in length and running nearly due east) was put in from the side of Yewthwaite Beck. The entrance to this adit has now fallen in. Later on another cross-cut (the Trustees'), of the same length, was driven 24 fms. below the Low Adit and 120 fms. farther north. The entrance is now partly blocked by debris, but the adit, wide and well arched, remains in fairly good condition. About 100 fms. south of the intersection of the Trustees' Adit with the lode, a shaft was

sunk from the Trustees' Level to a depth of 30 fms., and levels driven north and south at 10-fms. intervals.

The ore-bearing ground, about 130 fms. in length, appears to incline or 'shoot' southwards.

During its prosperous period the annual production was about 420 tons, valued at £5,880.

South-east of Yewthwaite Mine the lode has been tried at one place only—on Black Crag above Manesty, where a trial-level, made many years ago, met with little success.

North of Yewthwaite the lode crosses Newlands Vale, but on account of Glacial drift is seen only in the bed of the stream above the old mill (now a guest-house) at Stair. North of Stair the lode was worked at Barrow Mine (p. 26).

Castle Nook Mine.

(*Abandoned.*)

Situated about 1 mile south of Goldscope, in the higher part of Newlands Beck, between Goldscope and Dale Head.

Maps.—One-inch New Series Ordnance, 29; Old Series Geological, 101 S.E.; 6-in. Geological, Cumb. 69 N.E. and 70 N.W.

Geology and Mining.

There are here two north and south lodes carrying lead-ore, and a number of N.E. and S.W. veins (displaced by the former), some of which carry copper-ore. The western 'lead' vein, known as the Castle Nook, or West Castle Nook, Lode runs along the bottom of the Newlands Valley for 1½ miles, and may be seen in the beck above Goldscope. The eastern, or Francis, lead-vein (named after its discoverer) runs for about the same distance on the eastern side of the valley. The two veins are about 350 yds. apart; both hade to the east and traverse Skiddaw Slates.

In the West Castle Nook Lode the vein-filling is mainly smashed rock with very little quartz. It is spoken of by old miners as a 'clayey vein' with 'lumps of lead on the foot-wall.' From the top of the wheel-shaft in the adit it is said to have been worked to the south a distance of 62 yds., and in the 10- and 20-fm. levels 76 and 64 yds. respectively. The workings in the 10-fm. level are said to have intersected one of the copper-veins.

This lode has been mined at various times near Castle Nook, but on no great scale.

The Francis Lode contains more quartz than the West Castle Nook Lode. It has been tried on a small scale at intervals between Goldscope and Castle Nook, but never fairly opened out. The ores, cerussite, and galena, are said to occur in scattered bunches in somewhat crumbly quartz.

At Near Broad Gill there is a cross-cut to the vein, and farther up the hill there is a circular shaft, now blocked by debris. Between Near and Far Broad Gills there is a shaft 25 ft. deep on the vein, which here appears about 4 ft. wide and hades eastward at 15° from the vertical.

A level driven at the foot of the 'slack' in Castle Nook Crags did not give encouraging results, and was abandoned.

In 1863 Castle Nook produced 30 tons of dressed lead-ore.

Brandlehow or Brandley Mine.

(*Abandoned.*)

Situated at the foot of Catbells on the south-west shore of Derwentwater.

Maps.—One-inch New Series Ordnance, 29; Old Series, Geological, 101 S.E.; 6-in. Geological, Cumb. 64 S.W.

History.[1]

The mine was worked on a small scale previous to the advent of gunpowder in mining; its activity increased in the early days of the last century, when the Salt Level was driven, but the pumps then in use were unable to deal with the water met with, and the mine was abandoned in the early 'forties.' It was reopened by the Keswick Mining Co. in 1848, and a considerable amount of work done in extending the levels and sinking the northern shaft to 50 fms. A 30-ft. water-wheel was erected for pumping—subsequently replaced by a 26 h.p. steam-engine—but after 15 years' work the mine was closed down in 1864. After an interval of 20 years the 'Brandley Mining Co.,' under the direction of H. B. Vercoe, was formed, and a 50 h.p. steam-engine installed to unwater the mine. This company deepened the shaft to 78 fms., erected a dressing-plant propelled by a 30-ft. water-wheel, and in 1888 provided a 350 h.p. beam-engine for pumping—the smaller engine being used for haulage. After a few years' work the mine was finally abandoned.

Geology.

The mine is situated on the Brandlehow Lode, bearing N.N.W. and S.S.E., and hading eastward at about 2 ft. per fm. The lode, which is believed to lie east of Thornthwaite Mine (p. 6), can be traced from Skelgill, east of Stair, to about half-a-mile north of Grange in Borrowdale; and, in addition to the main workings at Brandlehow, has been mined at several other places.

The country rock (Skiddaw Slates) is traversed by numerous quartz-strings in the vicinity of the lode; these are regarded as 'feeders,' since bunches of ore frequently occur at their intersection with the vein.

[1] J. Postlethwaite, *op. cit.*, pp. 83–86.

An igneous dyke, akin to quartz-diorite and some 20 ft. in width, is seen in the quarry by the roadside west of the mine. There is a point of some interest in connexion with this igneous rock. Mr. Postlethwaite, in conversation, stated that it cuts the vein in the 50-fm. level, where it was 12 ft. across and difficult to get through, on account of water dammed back behind it; he has also expressed his belief[1] that 'as it contains a little galena and blende, it has no doubt borne an important part in depositing the ore in the vein.' No other case is known in the Lake District of an igneous rock younger than, or definitely enriching, a mineral vein. An inspection of a hand-specimen, obtained by Mr. Postlethwaite from the 50-fm. level, showed that the galena and blende occur in quartz-veinlets traversing the igneous rock, and not scattered promiscuously through it. In the quarry the dyke rock contains no trace of mineral, although it is crossed by numerous thin and barren quartz-strings. It is probable, therefore, that the dyke is of earlier date than the vein, and does not enrich it; in the mine it would be greatly shattered, and the abundance of igneous fragments, recemented to a solid mass, might give a deceptive impression that the dyke transgresses and is younger than the vein.

The vein, when productive, varies from 2 to 6 ft. in width, but is occasionally subject to 'nips,' and is then only a few inches wide. The vein filling is quartz—varying from hard compact white to softer spongy material—with some rock debris. The walls are fairly well defined and are usually lined with quartz. The general character of the vein may be seen in open stopes and old levels just outside the south-west corner of Brandlehow Park. About 200 yds. N.N.W. of the 'Salt Level' (measured along the vein) a 'split' is given off on the eastern side; this has been worked to a limited extent and is said to have carried as much ore as the main vein: it may be seen just inside the park at an old level where it is about $2\frac{1}{2}$ ft. wide and runs due north. Farther north, near the 500 ft. contour in the park, a branch from the main lode is given off to the west and can be traced by old bell-pits over the north end of Catbells. It is believed to cross the Vale of Newlands near Stonycroft Mine.

The northern limit of the workings from Brandlehow Mine is a little over 100 yds. along the main vein beyond the junction with the western branch.

The ores are galena and blende with a little cerussite, in addition to small quantities of pyrites, manganese-ores (mainly as skins or crusts) and barytes. An analysis of the galena showed 83·5 per cent. of lead and about 9 ozs. of silver per 20 cwts. of dressed lead-ore.

Mining.

The earlier mining was accomplished from the higher levels driven on the vein; subsequently, the Salt Level cross-cut was driven westward from the shore of the lake, ending in a level

[1] *Op. cit.*, p. 83.

driven northwards on the lode. Following the discovery of a small but rich ore body, nearly 4 ft. thick, south of the cross-cut, a shaft was sunk on the vein first to 20 fms., deepened later to 30 fms. At a later period, a new shaft was sunk near the southern boundary of Brandlehow Park, at first to a depth of 50 fms. and then to 78 fms. From these sinkings a length of 260 fms. was wrought out without reaching the limits of the ore-bearing ground; but, unfortunately, the vein has shown great variations in value—rich patches with ribs of ore $1\frac{1}{2}$ to 2 ft. in thickness, but of small extent, commonly occurring at the intersection of quartz feeders with the vein, alternating with ground either barren or with little ore.

The average produce of the mine when in full operation was about 300 tons a year; the lack of success appears to have been largely due to trouble with water, springs yielding some 150 gallons per minute having been met with. Formerly, this water was largely impregnated with chlorides of sodium and calcium, with smaller quantities of the chloride and sulphate of magnesium, but the salinity has decreased of late years.

The dumps on the lake-side near Brandlehow Landing are fairly extensive, but the bulk of the material is rock 'deads,' though quartz is more abundant than at Thornthwaite. Calcite is rare; skins and ribs of blende up to 1 in. in thickness are not uncommon, but not in sufficient quantity for reworking the dumps. Films of manganese-ore are of frequent occurrence.

About half a mile N.N.W. of the landing, the Brandlehow Lode was mined to some extent at the Old Brandley Mine. The vein is said to be contracted and poor at the bottom of the hill, but to increase in value in height and to split into two, one branch being more or less barren. Old surface-workings may be seen at intervals over the crest of Skelgill Bank, where the vein underlays N.E. at 65° from the horizontal. Opposite Withe Sike, four levels have been driven into the hillside and from the Top, or Coates, Level a considerable amount of ore was obtained. The Bottom, or New, Level, opening from a short cross-cut, was driven 100 fms. along a vein, but failed to reach the rich ore-body met with some 50 fms. above in Coate's Level: it is uncertain whether this level was driven on the non-productive branch or whether the ore-body has died out in depth. It was last worked by the Keswick Mining Co. about 1850. South of Brandlehow Mine several attempts on a small scale have been made to work the Brandlehow Lode, but over much of the ground the vein appears to have been poor and, as the surface is mostly low-lying, pumping charges would be high. The southernmost working is on the edge of the alluvium, 300 yds. E.S.E. of Manesty Farm. Here are three old shafts, now flooded, and an open stope and level, partly filled with refuse; in this locality the vein hades eastward at 10° from the vertical and is about 6 ft. wide. The country rock (Skiddaw-Slate) is intersected with quartz-strings, and a band of quartz

4 ins. thick is seen on the foot-wall. Galena is said to have occurred in a rib 3 ins. thick, in addition to blende. A little south of the entrance to the level, there is an open stope 2 ft. wide. This may be on a 'split' from the foot-wall side, or the vein may have been 'nipped.'

The Manesty 'copper-vein' crosses the Brandlehow Lode a little to the north of the above-mentioned shafts, but the actual point of intersection was not proved, though such places usually yield rich ore.

The last work done here was about 1850. It is doubtful if the vein will ever be reopened owing to the wet nature of the surrounding ground.

The output of Brandlehow Mine for 1855 and 1856, respectively, was 162 and 235 tons of dressed lead-ore. In 1857 the output was included with that of Barrow Mine. In 1858, 306 tons were raised, and from 1860 to 1866 the annual output was 295, 300, 283, 99, 50, 5 and $8\frac{1}{2}$ tons. In 1885 and 1886, respectively, 265 and 113 tons were sold, whilst in the three years from 1888 to 1890 the figures were 89, 80 and 80 tons. The amount of blende was small; the returns for 1888 show 7 tons.

Saddleback Old Mine.

(*Abandoned.*)

Situated 600 yds. N.E. of Scales Tarn on a tributary of the Glenderamackin.

Maps.—1-inch New Series Ordnance, 29; Old Series Geological, 101 S.E.; 6-in. Cumb. 57 N.W. & S.W.

Geology and Mining.

Some 40 or 50 years ago, attempts were made to work a lead-vein ranging from N.W. to S.E., through the chiastolite slate of this region. J. Postlethwaite[1] mentions that the vein is large and almost filled with dark-brown and orange limonite. The cost of carriage also is stated to have been prohibitive. At the present day the roundabout journey of about 7 miles down the Glenderamackin through Mosedale would be necessary.

The vein is believed to be prolonged south-eastwards across Scales Fell in Skiddaw Slates, and some years ago a level 400 yds. in length was driven on a small vein from Mousthwaite Comb, about half-a-mile N.N.E. of Scales, in the hope of striking the main vein; but without success.

Bannerdale Mine.

(*Abandoned.*)

Situated under Bannerdale Crags, north-east of Saddleback and 2 miles W.S.W. of Mungrisdale.

---

[1] 'The Deposits of Metallic and other Minerals surrounding the Skiddaw Granite,' *Trans. Cumb. and West. Assoc.*, vol xv, 1889–90, pp. 82, 83.

Maps.—One-inch New Series Ordnance, 29; Old Series Geological, 101 S.E.; 6-in. Cumb. 57 N.W.

Latitude 54° 39′ 20″, Longitude 3° 1′ 50″.

Geology and Mining.

The Bannerdale Lode runs from E. to W. through the 'Spotted Slates' of the Skiddaw Metamorphic Series and hades south at 20° from the vertical; the adjacent country-rock dips south at 50° and is traversed by numerous quartz-strings.

The vein is from 4 to 6 ft. across and contains smashed rock, in addition to strings of quartz and lenticular ribs of barytes from 6 to 8 ins. in thickness. Barytes occurs chiefly on the hanging-side and, though of fair quality, is not worth working alone. The metallic minerals are galena (for which the vein was worked) and blende, in addition to small quantities of iron-pyrites and traces of copper-ore. Graphite[1] is said to have been worked here for grate-polish and pencil-making; but, beyond a little irony carbonaceous matter on the walls and shiny surfaces on the slates, none can be seen at the present time.

Apparently the lode was only wrought under the Crags, in which there are two levels; the lower, apparently, served as an adit and is very wet, whilst the upper one, although open, is rather dangerous on account of rotten timber. Judging by the smallness of the dump, the length of vein worked was probably not great. In 1854, there were raised 7 tons of galena, and the last trial is said to have been made by a Mr. Crozier about the year 1870.

The mine is 5 miles from the nearest station (Troutbeck, on the C.K. & P. Ry.) and is somewhat inaccessible, as there is no road up the water-logged boggy valley beyond the Glendermackin. The local water-supply is poor, and the association of blende and barytes would necessitate a flotation-plant for satisfactory treatment.

Small Trials in the Keswick Area.

Maps.—One-inch New Series Ordnance, 29; Old Series Geological, 101 S.E.

(1) Embleton Mine.

Situated 200 yds. east of the third milestone from Cockermouth, on the main road to Keswick; 6-in. Geological Map. Cumb. 55 N.W.

About the year 1850, a small N. and S. vein was worked for lead-ore, but is said to have been poor and of small yield; in 1855 the output amounted to 5 tons of dressed lead-ore. The country-rock is Skiddaw Slate, with small masses of diorite or 'greenstone' in the vicinity of the lode. The vein was worked

[1] 'The Geology of the Northern Part of the English Lake District' (*Mem. Geol. Sur.*), 1876, p. 67.

on the south from a level near the 400-ft. contour, and from shafts in the higher ground at about 500 ft. O.D.

(2) Carl Side.[1]

Situated about half-a-mile north of Millbeck, 6-in. Geological Map, Cumb. 56.

Trials were made for galena some years ago in an E. and W. vein hading southwards at 30° from the vertical, and traversing Skiddaw Slates; the ore is said to have been in bunches and pockets in a gangue of quartz and barytes. Trials have also been made on a N.W. and S.E. quartz-vein near Mire House, but with poor results.

(3) Blease Gill.[2]

Situated on the west side of Gategill Fell, 1 mile N.N.W. of Threlkeld; 6-in. Geological Map, Cumb. 56 S.E.

Near the sheepfold, at the head of Blease Gill, a small vein, ranging approximately N. and S., was tried many years ago for lead-ore, but with little or no success.

B. Caldbeck Fells.

Roughtongill Mines (with Silvergill and Thiefgill).

(*Abandoned.*)

Situated 3½ miles S.S.W. of Caldbeck and 7 miles N.N.E. of Keswick.

Maps.—One-inch New Series Ordnance, 23; Old Series Geological, 101 N.E.; 6-in. Cumb. 47 S.E.

Dressing Floors: Latitude 54° 42′ 0 ; Longitude 3° 5′ 0″.

History.

In this mine there are old 'stope and feather' workings to a depth of 20 fms., dating back to pre-gunpowder days. In the time of Queen Elizabeth copper-ore was raised and sent to Keswick for smelting. About 1820[3] a company of working miners and others reopened Silvergill and Roughtongill Mines [probably the 30-fm. level]; but, after struggling for about eight years, a deeper level became necessary, and many members were obliged to sell their shares. Thomas Dickenson, of Alston, purchased one quarter of the mine, and a level 30 fms. deeper [the 60-fm. level] and extending 300 fms. was cut. From 1835 to 1845, 4,000 tons of lead- and copper-ores were raised, yielding a profit of £9,000 after paying all expenses, including dues at

[1] 'Mineral Resources of Great Britain,' vol. 2. 'Barytes and Witherite,' ed. 2, (*Mem. Geol. Surv.*), 1916, p. 24.

[2] 'Northern Part of English Lake District' (*Mem. Geol. Surv.*), 1876, p. 52.

[3] William Whellan, 'History of Cumberland,' 8vo, Pontefract, 1860, p. 227.

one-seventh. Subsequent owners drove the 90-fm. adit-level and erected, in addition to a large dressing-plant, a ' smelt ' mill with refining and desilverising apparatus. In the early ' seventies ' trouble was experienced by the men leaving for the better-paid work in collieries, and the staff fell from 200 to 47. Although a considerable amount of ore was raised subsequently the mine closed down about 1878; according to Postlethwaite,[1] it had been exhausted.

From 1888 to 1894 a few men were employed by the Cleator Iron Ore Co. for the purpose of raising barytes and umber. In 1889 the output of these substances amounted to: barytes, 166 tons; umber, 58 tons. In 1890: barytes, 137 tons; umber, 97 tons. In 1891 and 1892, respectively, 77 and 91 tons of barytes were sold. The output of lead and zinc ores (Plate I) includes that of other mines held by or associated with the same company. ' Caldbeck Fells ' includes many small undertakings.

Geology.

Roughtongill has long been famous for the variety of minerals found there, a characteristic which may possibly be connected with the diversity of the ' country-rock.' The Skiddaw Series of shales and grits occurs on the west and south-west; on the north are lavas and ashes of the Eycott (Borrowdale) Series, while on the east is the felsite mass of Great Lingy Hill, flanked by a coarse basic igneous rock akin to hypersthenite. This rock-complex is traversed in all directions by faults, some of which carry ores. The two main lodes range from W.S.W. and S.W. to E.N.E. and N.E., between Frozen Fell and Sandbed Mine, a distance of from 3 to 4 miles. Though generally about $\frac{1}{4}$ of a mile apart, they approach within 200 yds. of one another in the Roughtongill mining field. In the most productive part of the mine these two veins, which will be referred to as the North and South Lodes, flank the mass of hypersthene rock—trenched by the rugged Thief and Roughton Gills.

The veins are filled with broken rock and an abundance of quartz, either hard and white or the softer spongy variety. Chalcedony and agate are also common. Calcite, though rare in most parts of the Lake District, is here locally abundant. Barytes of good grade occurs and as a subsidiary product should repay attention. The ores, in order of importance, are those of lead, copper, zinc and manganese. Galena is the chief lead-ore, though some quantity of pyromorphite has been raised, in addition to a little cerussite. The leading copper-ores are copper-pyrites and malachite, though numerous other species have been noted here. Zinc-blende—generally the light-brown variety—is fairly common, and hemimorphite is occasionally seen. There are crusts of psilomelane, while the ochreous iron-manganese mixture known as umber was at one time raised.

[1] ' Mines and Mining, &c.,' *op. cit.*, p. 130.

The South Lode, hading N.W. at 20° from the vertical, has been wrought over a length of ¾ of a mile; the most extensive workings were by the hypersthenite of Battiway Rigg and were entered from cross-cuts on the east bank of Roughton Gill. The adit, or 90-fm. level (entrance now walled up), beginning near the old dressing-floors, was driven about 22° E. of S. for a distance of 120 fms. to cut the lode, and was then turned south-westwards along the vein for 250 fms. From the adit-level a shaft was sunk to a depth of 20 fms., and a considerable amount of ground stoped out. According to some MSS. notes left by Clifton Ward, in the lower workings, about 300 fms. from where the adit-level turns sharply to the south-west, the lode swells up to 30 ft. in thickness, over a length of 30 to 40 fms. This bunch was largely made up of calcite, ores occurring mostly in the middle and along the walls. On the north-east side the calcite was buff in colour and rich in copper-ores, malachite as well as chalcopyrite being abundant. At the south-west end the spar was blue and contained galena of low silver content, never exceeding 10 ozs. per ton of lead. 'Coloured lead' (pyromorphite, &c.) and copper-ores were diffused throughout the mass; blende occurred only in small quantity. The great 'bunch' is probably connected with the two parallel veins, 11 fms. apart, mentioned by Postlethwaite[1]; the cross-course of that author being the fault along the eastern Thief Gill. Above the adit is the 60-fm. level which commences just south of the crop of the North Lode and cuts the South Lode at 70 fms.; this level was driven 300 fms. along the vein and extends 110 fms. farther south-west than the adit-level. The 30-fm. level begins midway between the North and South Lodes. Other levels of ancient date, situated in the higher part of Roughton Gill and near the sheepfold in Thief Gill, have all collapsed at their entrances, and the dumps near them are small. To the north-east of Roughton Gill a level, directly on the vein near the summit of Iron Crag, is still open, but the others near Blea Gill and Clints Gill are closed. Between the two gills just mentioned the ground has fallen in to a depth of 20 ft., exposing what is probably the foot-wall of the vein.

The North Lode resembles the South Lode in its mineral contents, but judging by the small dumps at the mouths of old levels in Silver Gill, blende and galena appear to have been more abundant in depth than towards the outcrop.

When the North Lode crosses the head of Silver Gill it is intersected by a fault parallel to the beck. On the west of the lode is soft grey and blue-banded Skiddaw Slate; on the east is decomposed 'greenstone.' The ground let down between the lode and the fault consists of hard greenish tuff much jointed and partly cleaved. The lode at the surface here is 3 to 4 ft. wide and is full of quartz with 'shows' of malachite and manganese ore; the hade is N.W. at about 1 in 6 from

[1] *Op. cit.*, p. 129.

the vertical. There is a short level with three branches on the intersection of the fault and the lode, but little can be seen. In the small ravine cut by the gill, an old cross-cut runs about 20° E. of S. to cut the lode. A small dump marks the site of an old level near the 1,500-ft. contour. This level, from the existence of a sled-road to it, was probably the principal working, and would tap the vein at about 250 ft. below the upper cross-cut. Over the brow of the hill towards Roughton Gill the course of the lode is marked by shallow shafts and pits, and it must also have been penetrated by the adit to the South Lode, but nothing is known of any workings. The levels in Todd Gill have now fallen in, while about a mile farther to the north-east the lode has been tried above the head of Short Grain, but with doubtful result.

The dumps at Roughtongill are extensive, but appear to have been so thoroughly overhauled that they are valueless from a commercial standpoint, though interesting mineral specimens may still be gathered.

As far as water-power is concerned, Roughtongill is the most favourably situated lead-mine in the Caldbeck Fells, and if the mines are ever reopened it would be possible, by tapping the waters of Thief Gills and the higher part of Roughton Gill, to obtain a vertical head of water of about 400 ft. In the past a series of small reservoirs, fed by numerous low-level 'leats,' were in use, but these works are now broken down.

A continuous output of lead-ore was maintained at Roughtongill from 1850 to 1867 inclusive, a total of 6,402 tons being raised. The maximum yearly output in this period was 659 tons in1851, whilst the minimum was 161 tons in 1866. Figures for 1868 are included under the output of Caldbeck Fells (Plate I). In 1871 and 1875, respectively, 496 and 319 tons were raised. Outputs of 16 tons of zinc-ore in 1874, and 44 tons in 1876, include those of Drygill Mine. The output of zinc-ore for 1873 is included with that of Caldbeck Fells (Plate I).

Redgill Mine.

(*Abandoned.*)

Situated about half-a-mile W.N.W. of Roughtongill.

Maps.—One-inch New Series Ordnance, 23; Old Series Geological, 101 N.E.; 6-in. Cumb. 47 S.E. and N.E.

Latitude, 54° 42′ 10″; Longitude, 3° 5′ 35″.

Geology and Mining.

There are three main veins here—two trending between N.W. and S.E., and N.N.W. and S.S.E., and one from N.N.E. to S.S.W. The last is a fault of considerable throw mineralised over part of its course. The 'country' consists of lavas and ashes of the Caldbeck Borrowdale Series.

The northern N.W. and S.E. vein has been tried from a bell-pit about 150 yds. south of the junction of Red and Wet Small Gills. According to report this vein yielded galena with 30 ozs. of silver per ton of lead.

The southern N.W. and S.E. vein has received more attention; it may be seen in a shaft 25 ft. deep, in the bottom of Swinburn Gill, about 300 yds. south of the junction of that stream with Red Gill. The vein is here from 3 to 4 ft. wide and has a good smooth foot-wall hading eastwards at about 1 in 5 from the vertical; it is full of quartz-ribs and broken country-rock in a matrix of sand and clay stained with 'manganese.'

The lode here runs N.N.W. and S.S.E., and is believed to cross Yard Steel towards Roughton Gill; the cross-cut above the old smithy at the foot of Silver Gill was doubtless an attempt to locate this vein and test the intersection of the associated faults. Farther to the north-west, in the angle between Red Gill and Swinburn Gill, three cross-cuts have been driven. The entrances of the lowest (at stream-level) and of the highest are now blocked up, but the middle cross-cut is still open and shows signs of working of fairly recent date. About 6 yds. from the entrance the main vein is reached, with levels north and south; that to the north is open for several yards, but the other is blocked by fallen debris. The vein is here from 4 to 5 ft. thick; it courses N.W. by N., and hades eastward at about 1 in 5. About 8 yds. farther along the cross-cut a smaller vein, with traces of malachite, was met with, coursing and hading in about the same direction and amount as the main vein. A short level has been driven northwards.

Ore from all these workings appears to have been shot from the higher levels down Red Gill.

The N.N.E. and S.S.W. vein, running along the east side of Swinburn Gill, does not appear to have been worked in depth. It is believed to hade to the west and seems to have been reached by a cross-cut halfway up the hill. A higher level (indicated on the old 6-in. map) in the steepest part of the gill is no longer traceable.

The dumps are small and are mainly of 'rock deads' and quartz. A little galena, with traces of pyromorphite, occurs in addition to malachite and the rare mineral linarite (a basic sulphate of lead and copper). Blende appears to be practically absent. Barytes, both good white and slightly pink varieties, occurs in small quantities; from an examination of the old workings and local dumps it appears to belong to the southern N.W. and S.E. vein, and to have increased in quantity upwards in the vein.

Little reliable information is available concerning this mine, but according to Mr. Postlethwaite,[1] a quantity of copper and lead was raised here in the past, though the actual published figures are small. Thus the output of dressed lead-ore in 1861

[1] *Op. cit.*, p. 130.

was $1\frac{1}{4}$ tons; in 1862 and 1863, respectively, 15 and 9 tons; apparently nothing in 1864 and 1865; whilst in 1866 only $2\frac{1}{2}$ tons appear to have been raised. The mine is not mentioned in later years, though possibly included under Caldbeck Fells.

Trials for Lead-ore near Roughtongill.

About $\frac{3}{4}$ of a mile north of Red Gill there are some old lead-workings, known as Braefell Mine, on a vein which courses N. of W. and probably hades southwards. It does not appear to have been worked in the bottom of the valley; on the side of the hill, however, there are two collapsed levels about 60 ft. apart, with small dumps at the entrance. These dumps are mainly 'dead rock' and rough granular quartz. The chief ore appears to have been galena. Traces of pyromorphite and malachite were noticed, but no blende or barytes.

At the foot of Birk Gill a vein ranging a little S. of W., and believed to be the same as the barytes vein of Potts Gill, has been tried for lead-ore with but little success; it consists mainly of granular quartz.

In Short Grain, 400 yds. east of its junction with Long Grain, a cross-cut has been driven northwards; no information, however, is available as to whether it reached the vein, which is believed to crop out about 100 yds. to the north. The entrance is partly blocked by debris.

About 150 yds. farther up Short Grain, there was a cross-cut (now fallen in) to a north-and-south vein. Judged from the small dump, the vein-stuff is here in part a conglomerate of fine hard brown and softer grey-green tuff, with a cement of quartz and barytes; other parts appear to be quartz with strings of barytes. The same vein has been tried from a shallow shaft on the top of Deer Hills, 500 yds. west of Potts Gill, with little success.

About the year 1868 small trials for lead-ore were made in Brandy Gill by Messrs. Leicester, Hutchinson & Co. The vein is believed to run roughly E. and W. about midway between Drygill and Grainsgill, and to be about 200 yds. in length between N. and S. veins which carry tungsten farther south at Carrock. It is reported that there was a promising show of galena at first, but that a short exploration revealed the ore-body to be small.

Drygill Mine.

(*Abandoned.*)

Situated $3\frac{1}{2}$ miles south of Caldbeck and $\frac{1}{4}$ mile S.W. of Driggith Mine.

Maps.—One-inch New Series Ordnance, 23; Old Series Geological, 101 N.E.; 6-in. Cumb. 47 S.E.

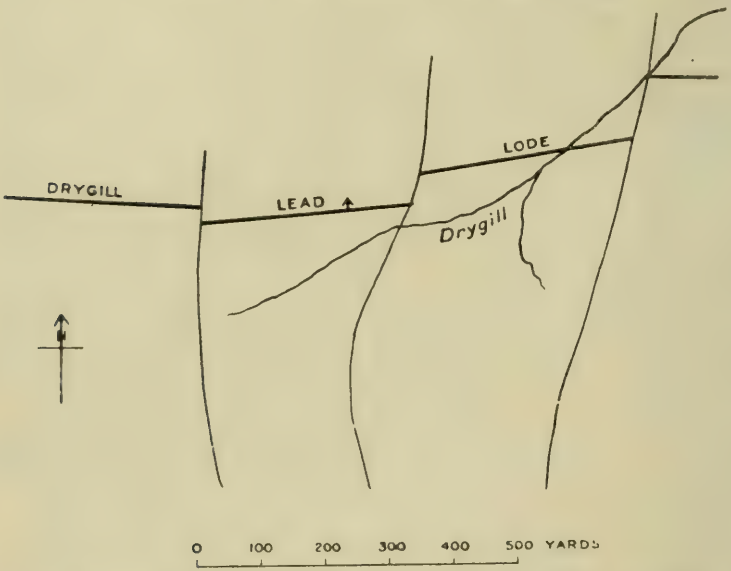
Centre of Mine: Latitude 54° 42′ 5″, Longitude 3° 3′ 0″.

Geology and Mining.

The Drygill Vein, forming the faulted boundary between Drygill Shales on the south and the Borrowdale volcanic rocks on the north, ranges roughly E. and W.; it is believed to be a continuation of the Carrock copper-lode, and on the west runs into the Driggith-Roughtongill vein. Midway along its course it is displaced 20 to 50 yds. by three veins trending northward from Brandy Gill.

The Drygill Vein is 4 or 5 ft. wide and hades north at 10° to 15° from the vertical; the foot-wall is well defined. There is

Fig. 4.—Sketch Map of Drygill showing Shifts of the East and West Lead-lode by North and South Veins which carry Tungsten in the Greisen farther South.



an abundance of quartz, either spongy or hard and white. In the lowest level (by the conduit to Driggith) there is about 1 ft. of soft pale 'muck'—a mixture of sand, clay and quartz—on the foot-wall. Good white barytes occurs in small quantity on the dump and appears to have occurred in thin irregular ribs. Galena was the ore chiefly worked, but in addition, pyromorphite and mimetite (particularly the variety known as 'kampylite' occurring in brown and yellow barrel-shaped crystals) are common, especially on the foot-wall at the outcrop. Psilomelane coats the other minerals freely, but there is little solid ore; pink alteration-products of manganese are seen occasionally. Some copper-ore, mainly chalcopyrite, was raised in the past.

Mining was carried on from cross-cuts (now buried in debris) on the north side of Drygill, and from a day-level on the vein near the open conduit to Driggith. This is still open but very

wet. The mine has been long abandoned. It is reported locally that the 'coloured lead minerals' were sent to glass manufacturers.

In 1848–9 a total of 90 tons of dressed lead-ore was produced; whilst in 1850, 1860 and 1875 respectively the outputs amounted to 2, $2\frac{1}{2}$ and $5\frac{3}{4}$ tons. Intervening years were barren. A little zinc ore, included with that of Roughtongill, was raised in 1874 and 1876.

Driggith Mine.

(*Abandoned.*)

Situated at the head of Driggith Beck (a tributary of Carrock Beck) about $3\frac{1}{4}$ miles south of Caldbeck.

Maps.—One-inch New Series Ordnance, 23; Old Series Geological, 101 N.E.; 6-in. Cumb. 47 N.E. and 48 N.W.

Old Dressing Floors: Latitude, 54° 42′ 25″, Longitude 3° 2′ 25″.

History.

Driggith Mine[1] was opened in 1700 by a Mr. Row, who wrought it from shallow shafts and day-levels to a depth of 25 fms., and erected a small smelting-works near Carrock Beck. From 1810 to 1822 Messrs. Richardson, Lowry and others worked it, and installed crushing-plant to prepare the ore for dressing and smelting. From 30 to 40 pickmen were employed, and 500 bings or 200 tons of ore are said to have been raised annually for five years. On smelting, every ton of ore produced 12 cwt. of lead (60 per cent.) and yielded 45 to 50, and even as much as 60, ozs. of silver per ton of pig-lead. At a later period (about 1860), with improved dressing and smelting, the same class of ore produced 75 to 78 per cent. of lead, yielding 25 to 30 ozs. of silver per ton. It is evident that in the old process much lead must have been burnt in smelting; while since the whole of the silver would remain in residue, the amount of this metal would be relatively high.

From 1822 to 1834 the mine belonged to T. R. G. Braddyll, of Conishead Priory, who drove the Sandbed Level; it was then held for four years by John Barret, who was succeeded by Dickenson & Co.; this firm lasted until 1849, but for many years worked at a loss. In 1849 the mine was taken over by Messrs. Brocklebank and Jeffrey and put in a more efficient condition as regards mining, dressing and smelting. During the eight years ending December 1857 some 1,950 tons of lead- and copper-ore was raised, and 35 men and 15 boys were employed on the average. This firm drove the 90-fm. level about the year 1860, and continued working to about 1870.

[1] We are indebted to Mr. J. Hemingway, of Mungrisdale, for reference to Whellan's 'History of Cumberland,' 1860, from which most of the historical notes on this and other Caldbeck mines were compiled.

The mine, after lying abandoned for many years, was last worked by the Caldbeck Mining Company from about 1904 to 1908. Some galena, blende, barytes and copper-ore was raised, but no figures are available concerning the output beyond those given below (p. 45).

Geology.

The main vein worked at Driggith Mine courses from N.E. to S.W., and was also wrought at Sandbed and Roughtongill Mines. It is believed to be a mineralised fault between a lava and an altered ash in the Borrowdale Series of Caldbeck Fells.

The vein is said to average 4 ft. across, though swelling at times to 8 ft., and at others being nipped to a few inches. At the extensive crop-workings the vein is seen nearly vertical, there being a slight hade to the N.W., and in places it is 8 ft. wide; a 6-in. rib of barytes on the hanging-wall is followed by quartz and two 6-in. ribs of impure psilomelane. There are irregular ribs of barytes on the foot-wall, and crusts of green pyromorphite on quartz are common. In depth the vein is said to have carried quartz and barytes on the walls, with blende, galena and copper-ores in the middle, blende being reported to be the most abundant. A local miner states that in the deeper workings a vein of practically solid barytes, averaging 2 ft. in thickness, lies 20–40 yds. ' behind ' (*i.e.*, to the north-west of) the main vein; this may be an offshoot downwards from the main lode.

The dumps, mainly of quartz, are fairly extensive. Some good-class barytes is present though sometimes mixed with quartz. Radiating veins of blende in quartz are fairly abundant; they are usually half-an-inch thick. A little copper-pyrites and malachite is present.

Mining.

After the crop-workings and shallow shafts of the early mining were made, a cross-cut (still open) was driven west, about 50 yds., to cut the vein above the head of Driggith Beck. At the bifurcation of the dry valley on the north side of Driggith Beck there is another cross-cut at a lower level, but the entrance has collapsed. There appears to have been a still lower cross-cut at the junction of the above-mentioned dry valley and Driggith Beck. These may be what are spoken of locally as the 30-, 60- and 90-fm. adit-levels, though the altitudes are less in reality. As this mine was wrought in conjunction with Sandbed Mine the length of vein worked may be taken as about half a mile, but the vein was probably not exhausted. Driggith was wrought to 90 fms., though, according to Postlethwaite,[1] the bulk of the ground excavated was above the 60-fm. level, the 90-fm. level being less productive.

---

[1] *Op. cit.*, p. 130.

When last worked there was apparently a tramway from the lowest level to the dressing-floor. The dressing-plant, with the exception of a stone-breaker, has been removed, but lump barytes seems to have been picked out and the ores crushed and jigged, the 'fines' being treated in 'dollies.' A few tons of jigged blende remain, but are somewhat mixed with barytes. Power for dressing was supplied by a traction steam-engine. The obstacles to working this mine appear to be due to (1) insufficiency of water (a 'leat' from Drygill seems to have been the chief supply), and (2) the association of blende and barytes, which, in the absence of cheap hand-picking, requires a flotation plant.

The earliest published official statistics give Driggith Mine an output of 40 tons of dressed lead-ore in 1848, and 140 tons in 1850. A continuous output was maintained from 1853 to 1870, with one break only, in 1867. In this period the total amount of ore raised was 2,987 tons; the maximum yearly output being 286 tons in 1854. In 1906–7 a total of 14 tons of zinc-ore was obtained.

Sandbed Mine.

(Abandoned.)

Situated to the north of Driggith Mine, 1 mile S.W. of Woodhall and 3 miles S. of Caldbeck.

Maps.—One-inch New Series Ordnance, 23; Old Series Geological, 101 N.E.; 6-in. Cumb. 48 N.W.

Old Dumps: Latitude 54° 42′ 55″, Longitude 3° 2′ 20″.

Geology and Mining.

At this mine the same N.E. and S.W. vein as that of Driggith was worked; it is visible in a dry valley to the south-west of the main top dump, hading slightly to the N.W., and from 4 to 5 ft. in width (mostly white quartz) in a very rotten country-rock. A southerly offshoot or string, forming a ridge of white quartz, may be seen near by, but it is doubtful if this contains ore. All the levels are now blocked with debris.

There are extensive dumps of quartz and rock 'deads' with a fair quantity of barytes—good class white apparently from ribs from 6 ins. to 8 ins. thick—and some blende similar to that of Driggith. There is a little galena, some traces of pyromorphite and crusts of psilomelane. A small quantity of copper-pyrites and malachite is present, but it is doubtful if much copper was raised here.

The mine suffered from the same difficulties in working as Driggith. Water was brought in a 'leat' over a mile in length from Carrock Beck. The mine was abandoned about 50 years ago.

C.—*Helvellyn Field.*

Grisedale Mines.[1]

(Abandoned.)

Situated about 2 miles south of Greenside Mine.

Maps.—One-inch New Series Ordnance, 29; Old Series Geological, 101 S.E.; 6-in. Westmorland 12 S.W. (Geological) and 19 N.W.

Latitude 54° 31′ 0″, Longitude 2° 59′ 15″.

Geology and Mining.

Three veins traverse the rough ashes of the Borrowdale Series on the eastern slopes of Helvellyn. They received a little attention at the beginning of the 19th century, but have not been worked during the last 40 years. The dumps are small and mainly 'deads.' Galena was the only ore raised.

The chief or Eagle Crag Vein runs, approximately, E. and W. from Blind Cove to Calf Hole, a distance of about 1 mile, and hades southward at a small angle from the vertical. It was worked from a short cross-cut at 850 ft. O.D. on the east side of Grisedale Beck, and also from two levels on the vein to the west of the beck—one at 900 ft., and the other, on the crags, at 1,750 ft. O.D. A little to the west of the highest level the Eagle Crag Vein meets a N.E. and S.W. lode from the north, known as the Clay Vein. This was worked from a cross-cut at about 1,200 ft. O.D. on the north bank of the stream from Calf Hole. The Tongue, or Ruthwaite Lodge, Vein ranging E.N.E. and W.S.W., crosses Grisedale Beck about ¼ of a mile south of the Eagle Crag Vein. The oldest workings are near Ruthwaite Lodge at about 1,250 ft. O.D., but trials were made from a level on the east bank of the beck about 40 or 50 years ago.

A rather rough road leads down the valley to the head of Ullswater—a distance of about 2¼ miles.

Hartsop Hall Mine.[2]

(Abandoned.)

Situated 400 yds. west of Hartsop Hall and ½ a mile S.W. of Brothers Water.

Maps.—One-inch New Series Ordnance, 29; Old Series Geological, 101 S.E.; 6-in. Westmorland 19 N.E.

Latitude 54° 30′ 0″, Longitude 2° 56′ 0″.

Geology and Mining.

The lode courses from N.N.E. to S.S.W. and hades westward at 25° from the vertical in Borrowdale Ashes permeated by numerous quartz-strings. It is said to have contained some good ore sporadically distributed: there was but little blende with the galena.

---

[1] *See* 'The Northern Part of the English Lake District' (*Mem. Geol. Surv.*), 1876, p. 55.

[2] *Ibid.*, p. 55.

Some of the workings are very old; others (including two levels between 700 and 800 ft., O.D.) belong to a later period, but no work has been done here for over 50 years.

Helvellyn or Wythburn Mine.

(*Abandoned.*)

Situated 1 mile east of the head of Thirlmere.

Maps.—One-inch New Series Ordnance, 29; Old Series Geological, 101 S.E.; 6-in. Cumb. 71 S.W.

Latitude 54° 31′ 30″, Longitude 3° 2′ 10″.

History.

The mine was opened[1] about the year 1860, and the company spent £20,000 in development and in erecting a self-acting tramway, 600 yds. in length, to the dressing-plant. During the 13 years the company was in operation levels were driven an aggregate distance of 630 fms., but the amount of ore raised was only 300 tons, worth about £4,000. The company was afterwards reorganised, but when the Manchester Corporation acquired the Thirlmere drainage-area mining operations were brought to an end.

Geology and Mining.

Three veins were worked here: two of these range N.N.E. and S.S.W. and hade eastward, the western, or Blue Rock Vein being 15 yds. from the eastern, or Old Vein, though they probably unite north and south of the mine. The third, known as the 'East and West Vein,' courses from W.S.W. to E.N.E. and hades southward; it intersects the other lodes near the entrance to the highest level, and it is said that there was a rich ore-body at the junction. Mining was difficult owing to the hard nature of the 'country' (altered ashes or felstones of the Borrowdale Series) and to the scattering of the galena through very hard veinstuff. In working the Blue Rock and Old Veins, several serpentinous elvan dykes were encountered and found to have completely 'deadened' the lodes.[2]

Five levels were driven, the lowest being at about 1,400 ft. and the highest at about 2,100 ft. above sea-level: some ore was raised from the N.N.E. lodes, chiefly from the Old Vein, which is said to contain some highly argentiferous galena. The 'East and West Vein' has been proved for short distances only.

Low Hartsop Mine.[3]

(*Abandoned.*)

Situated near Brothers Water at the junction of Hayeswater Gill and Pasture Beck.

---

[1] J. Postlethwaite, 'Mines and Mining, &c.,' *op. cit.*, p. 126.

[2] 'Geology of the Northern Part of the English Lake District' (*Mem. Geol. Surv.*), 1876, p. 54.

[3] 'The Geology of the Country round Appleby, Ullswater and Haweswater' (*Mem. Geol. Surv.*), 1897, p. 104.

Maps.—One-in. New Series Ordnance, 30; Old Series Geological, 102 S.W. 6-in. Westmorland 19 N.E.

Geology and Mining.

This mine is of ancient date and has been disused for 50 years.

The main vein runs, roughly, from N.N.W. to S.S.E. through rocks of the Borrowdale Series: as a barren quartz-vein it is seen in Pasture Beck near the confluence with Hayeswater Gill and close to the old shaft. Southwards—about a mile up stream—it is said to be a "strong vein of calc-spar 2 ft. thick . . . . The northern continuation is doubtful. The shaft is 30 fms. deep and the level runs S. 10° E. for 150 fms."[1]

The northern level at one time admitted much water and was drained by a water-wheel pump.

The vein is said to have contained galena, with a silver content of 16 ozs. per ton, associated with copper-pyrites and blende.

There are signs of other lead veins in this locality. One between Low Hartsop and Brothers Water runs from N.W. to S.E. It was tried many years ago from a short level. Another on the north bank of the beck N.W. of the Low Hartsop Mine runs, approximately, N.E. and S.W.

D. Scattered Occurrences.

Loweswater Mine.[2]

(*Abandoned.*)

Situated near Scalehill Bridge at the foot of Crummock Water.

Maps.—One-inch New Series Ordnance, 29; Old Series Geological, 101 S.E.; 6-in. Geological, Cumb. 63 S.W.

Loweswater Mine: Latitude 54° 34′ 55″, Longitude 3° 19′ 10″.

Geology and Mining.

The Loweswater Vein ranges from N.W. to S.E. through the Skiddaw Series. The main workings are in the low ground where a shaft was sunk to 17 or 18 fms. and a quantity of ore extracted. A water-wheel was erected for pumping, hoisting, and propelling the dressing-plant. The vein has also been tried from a level in the higher ground of Whinny Ridding, to the north-west.

The mine was abandoned about 80 years ago and has not been reopened, except for some trials made about 1888. The workings were very wet, and are now flooded.

About threequarters of a mile to the south-west, a vein, with a similar trend, was tried about the year 1860 in Park Beck

[1] *Ibid.*

[2] *See* 'Geology of the Northern Part of the English Lake District' (*Mem. Geol. Surv.*), 1876, p. 52, and J. Postlethwaite, *op cit.*, p. 106.

near Kirkhead. A parallel vein farther south-west, between Whiteoak and High-nook Becks (eastern margin of 62 S.E.), was worked about the same time; but, although a good deal of ore is said to have been raised, the workings are not extensive. Another small galena working, made about the year 1840, may be seen on the west side of Mosedale Beck, about a quarter of a mile north of Thrang Crags (6-in. Geological Map, Cumb. 69 N.W.).

Windermere District.

Maps.—One-inch New Series Ordnance, 39; Old Series Geological, 98 N.E.

In 'The Geology of the Country around Kendal, Sedbergh, Bowness and Tebay,' it has been noted[1] that "the few lead veins which have been noticed in this area occur in the Bannisdale Slates. A vein of pink sulphate of baryta, with a little galena, has been opened by the roadside a quarter of a mile south-west of Knipe Tarn" [2 miles S.E. of Bowness; 6-in. map, Westmorland 37 N.E. The vein runs approximately E. and W., and is up to 8 ft. in thickness; the greater part is country-rock, with thin strings of barytes and galena and a little quartz. Some work was done on the outcrop, and a level driven into the hillside with a connecting shaft 60 ft. in depth. The dumps of this abandoned mine have been used for road-metal for more than 20 years]. "About 2 miles to the north-east, in a hollow south of Borwick Fold, a shaft has been sunk in search of lead-ore, and an engine erected." [2 miles W.S.W. of Staveley Station, 6-in. map Westmorland 33 S.W. Two veins cross here, one running E.N.E., the other N.N.W., and the shaft, 126 ft. deep, was sunk at the intersection; these works were given up long ago.] "Lastly, a vein running E. 30° S. has been worked on Staveley Head Fell, and by a level opening into the Kent valley, south of Millrig." [Midway between Kentmere and Staveley; 6-in. maps, Westmorland 27 S.W. and 33 N.W.] "In all these cases, the works have been abandoned as unprofitable."

Coniston District.

Maps.—One-inch New Series Ordnance, 38; Old Series Geological, 98 N.W.; 6-in. Lancs. 1 S.E.

In the ashes of the Borrowdale Series, near Coniston, there are several veins carrying ores of lead and zinc; they do not seem to have been recorded hitherto, and are as yet practically unworked. One of these, believed to range from N.E. to S.W., was met with at Coniston Copper Mines in searching for the Bonser Vein on the far side of a cross-course at the Deep Level; it is said to be several feet in width and to carry ribs of galena and blende up to 8 in. in thickness. A vein, believed to be the same, crops out a quarter of a mile farther N.E. below the

[1] *Mem. Geol. Surv.*, ed. 2, 1888, p. 18.

peat-moss in Hole Rake, but little work has been attempted at either place except for a small trial-hole near Moor Quarries.

In Tilberthwaite Gill, a short distance above the sharp bend to the north, where the stream enters the slate-beds, a 'lead' outcrop has been recently located in a shatter-belt about 10 yds. in width, west of a copper-ore string near the slates. Galena in lumps and strings is confined to the western side, but appears to be in sufficient quantity to warrant further exploration. Beyond a little prospecting by Mr. J. W. Shaw, of Coniston, nothing has been done here.

A small east-and-west vein has been tried on Tilberthwaite Fells, about 300 yds. S.W. of the hamlet of Low Tilberthwaite. The vein consists mainly of smashed rock and quartz, carrying galena and blende in small strings and bunches.

INDEX.

Agate, 37.
Anglesite, 2.

Bala rocks, 1.
Bannerdale, 6, 34, 35.
Bannisdale Slates, 1, 49.
Barrow, 6, 26, 27, 28, 30.
———— Mining Co., 26.
Barytes, 2, 3, 12, 13, 16, 20–23, 26, 32, 35–37, 40–42, 44, 45, 49.
Barytes-galena veins, 2.
Bassenthwaite Lake, 6, 7, 10.
Battiway Rigg, 38.
Beckstones, 7, 9.
Birk Gill, 41.
Bishop Rock, 9.
Black Crag, 30.
Blea Gill, 38.
Blease Gill, 36.
Blencathra, 19, 20.
Blind Cove, 46.
Borlase, W. H., 15, 17, 19.
Borrowdale Series, 1, 15, 37, 39, 42, 44, 46–49.
————String, 24, 25.
Borwick Fold, 49.
Bowness, 49.
Braithwaite, 10, 20, 23.
Brandlehow, 3, 6, 31–34.
Brandley, 6, 31, 33.
———— Mining Co., 31.
Brandy Gill, 41, 42.
Brothers Water, 46–48.
Brundholme, 5, 19, 20.
———— Co., 19, 20, 23.

Calamine, 2.
Calcite, 2, 16, 26, 37, 39.
Caldbeck Fells, 1–3, 5, 6, 19, 36–45.
———— Mining Co., 44.
Caldew, 5.
Calf Hole, 46.
Cambro-Ordovician strata, 1.
Carboniferous Limestone, 4.
Carlside, 36.
Carrock, 41–45.
Castle Nook, 6, 30, 31.
Cerrusite, 2, 8, 20, 21, 27, 29, 30, 32, 37.
Chalcedony, 37.
Chalcopyrite, 2, 3, 38, 42.
Chalybite, 2, 21.
"Chatts," 18.
Chiastolite slate, 12, 34.
Chrysocolla, 20.
Cleator Iron Ore Co., 37.
Coledale, 20, 21.
———— Mining Syndicate, 21.
Comb Beck, 9.
Coniston, 3, 6, 49.
———— Copper Mines, 49.
———— Limestone, 1.
Copper producer, Lake District, a, 1.
———— -pyrites, 13, 16, 20, 35, 37, 44, 45, 48.
———— veins, 2, 5, 23–25, 29, 30, 34, 36, 42, 44, 50.
Crummock Water, 21, 48.
Crystallisation, order of, 3, 21.
Cumberland Lead Mine Co., 7.

Dale Head, 30.
Date of mineralisation, 4.
Deer Hills, 41.
Depth, effects of, on ore-bodies, 3.
Derwentwater, 6, 31.
———— Copper, Lead and Zinc Co., 28.
Desilverising of ore, 6, 18.
Diorite, 7, 32, 35.
Dolerite, 7.
Dolomite, 3, 8, 21.
"Douk," 7, 8, 10, 25, 29.
Dressing of ores, 5; *see also* Details of Mines.
Driggith, 2, 6, 41–45.
Drygill, 1, 6, 39, 41–43.
Dykes, igneous, 3, 7, 12, 15, 32, 37.

Elmore process, 5, 23.
Enrichment of veins, 3.
Eycott Series, 1, 37.

Fault-breccias, 2.
Feeders of lodes, 17, 31.
Felsite, 1, 3, 15.
"Flookan," 15.
Flotation process, 5, 23.
Fluorspar, 3, 21.
Force Crag, 2, 3, 5, 20.
Francis, W., 7.

Gabbro, 1, 3, 4.
Gategill, 11–14.
———— Fell, 36.
Glencoindale Head, 14, 15.
Glenderaterra, 19.
Goldscope, 4, 5, 29, 30.

Grainsgill, 41.
Graphite, 35.
Great Lead Bunch, 4, 23, 24.
—— —— Lingy Hill, 37.
Green, J. F. N., 5.
Greenside, 2, 3, 5, 6, 14, 46.
Greenstone dykes, 12, 35, 38.
Grisedale, 6, 46.

Hallsfell Top, 12.
Harker, Dr. A., 4.
Hartsop Hall, 6, 46.
Hayeswater Gill, 47, 48.
Helvellyn, 1, 5, 18.
———— Field, mines in, 6, 46–48.
Hemimorphite, 2, 37.
Hemingway, J., 43.
Hewitson, Mr., 12.
High Crags, 29.
—— Nook Beck, 49.
Hole Rake, 50.
Hypersthene-gabbro, 3.
Hypersthenite, 1, 37, 38.

Iron Crag, 38.
Iron-pyrites, 2, 15, 16, 35.

Johns, B., 19.

Kampylite, 2, 42.
Kendall, J. D., 8, 24, 25.
Kent Valley, 49.
Kentmere, 49.
Kepple Cove Tarn, 18.
Keswick, 1, 3, 5, 15, 20, 35, 36.
———— Field, mines in, 6, 26–36.
———— Mining Co., 7, 26, 27, 31, 33.
———— United Silver Lead Mine Co., 7.
Kirk Head, 49.
Knipe Tarn, 49.
Knott End, 29.

Ladstock, 7.
Lanthwaite Gate, 21.
Limonite, 2, 34.
Linarite, 40.
Little Town, 28, 29.
Lodes or Veins :—
  Bannerdale, 35.
  Barrow, 26.
  ——— Yewthwaite, 7, 26, 28.
  Blue Rock, 47.
  Brandlehow, 28, 31–33.
  Castle Nook, 30, 31.
Lodes or Veins—*cont.*
  Clay, 15, 17, 46.
  Driggith-Roughtongill, 3, 42.
  ———-Sandbeds, 2.
  Drygill, 42.
  Eagle Crag, 46.
  " East and West," 47.
  Force Crag, 2, 21, 22.
  Francis, 9, 30.
  Gategill, 11, 13, 14.
  Goldscope, 23–25, 29.
  Greenside, 3, 15–17.
  Johnson Ross, 15.
  Ladstock, 7, 9.
  Long Crag, 21, 22.
  Loweswater, 48.
  Lucy Tongue, 17.
  North, 37.
  ——— Cross-course, 15.
  Old, 47.
  Rachel, 7–9.
  Ruthwaite Lodge, 46.
  Sandy, 26.
  Sealby's, 5, 24, 25.
  South, 37.
  Stonycroft, 28.
  Thornthwaite, 2, 3, 7–10.
  Tongue, 46.
  Woodend, 11–14.
  Yewthwaite, 28–30.
Lodes, variability of, 3.
Long Grain, 41.
Lonscale Crags, 19.
Low Hartsop, 6, 48.
Loweswater, 6, 48–49.
Lucy Tongue Gill, 15.

Malachite, 2, 20, 37, 38, 40, 41, 44, 45.
Manesty, 30, 33, 34.
Manganese, 2, 32, 33, 37, 38, 40, 42.
Marr, Prof. J. E., 4.
Millbeck, 36.
Millrig, 49.
Mimetite, 2, 42.
Mines, details of :—
  Bannerdale, 34, 35.
  Barrow, 26, 27, 30.
  Beckstone, 7, 9.
  Blease Gill, 36.
  Blencathra, 19, 20.
  Braefell, 41.
  Brandlehow, 31–34.
  Brandley, Old, 33.
  Brundsholme, 19–20.
  Castle Nook, 30–31.
  Driggith, 43–45.
  Drygill, 41–43.
  Embleton, 35–36.
  Force Crag, 20–23.
  Goldscope, 23–26.

Mines, details of—*cont.*
Greenside, 14–19.
Grisedale, 46.
Hartsop Hall, 46–47.
Helvellyn, 47.
Ladstock, 7, 9.
Low Hartsop, 47–48.
Loweswater, 48–49.
Newlands, 23–26.
Redgill, 39–41.
Roughtongill, 36–39.
Saddleback, Old, 34.
Sandbed, 45.
Silvergill, 36.
Stonycroft, 27–28.
Thornthwaite, 6–11.
Threlkeld, 11–14.
Wythburn, 47.
Yewthwaite, 28–30.
Mineral-fields, 1, 6.
Mineralisation, date of, 4.
Minerals, in veins, 2, 3,
Mining, 5; *see also* Details of Mines.
Mire House, 36.
Moor Quarries, 50.
Mosedale, 34.
———— Beck, 49.
Mousthwaite Comb, 34.
Mungrisdale, 34.
Murchison, J. H., 18.

Newland (and Brundholme) Mines Co., 23.
Newlands, 5, 6.
———— Beck, 28, 30.
————, Vale of, 26–28, 30, 32.

Oil-flotation process, 5, 23.
Ores, proportion of, in veins, 8, 21.
Ore-bodies, 13, 17, 20, 23, 27.
Order of crystallisation, 3, 21.
Ordovician rocks, 1.

Park Beck, 48.
Pasture Beck, 47, 48.
Postlethwaite, J., 1, 6, 7, 12, 19, 23, 26–28, 31, 32, 34, 37, 38, 40, 44, 47.
Potts Gill, 41.
Psilomelane, 2, 3, 21, 22, 37, 42, 44, 45.
Pyrites, 8, 12, 13, 21, 27, 32.
Pyromorphite, 2, 27, 29, 37–42, 44, 45.

Rachel Wood, 7, 8.
Redgill, 6, 39–41.
Red Tarn, 18.
Roughten Gill, 19.
Roughtongill, 2–4, 6, 36–40, 43, 44.
Rowling End, 28.
Ruthwaite Lodge, 46.

Saddleback, 6, 12, 34.
———— Mining Co., 11.
Saline springs, 33.
Sandbed, 6, 37, 44, 45.
Sanderson, R., 29.
Scalehill Bridge, 48.
Scales, 34.
Scope Beck, 26.
——— End, 24.
Shaw, J. W., 50.
Short Grain, 39, 41.
Silver, 2, 3, 8, 13, 16, 21, 25, 32, 38, 43, 48.
——— Gill, 38, 40.
Sinen Gill, 19, 20.
Skiddaw District, mines in, 6.
———— Granite, 1, 20.
———— Slate Series, 1, 9, 12, 20, 21, 25, 28, 30, 31, 33–38, 48.
Slime-settling pits, 10, 14.
Smelting of ore, 6, 15, 18, 43.
" Sops " of ore, 3, 11, 17, 29.
Spars, 2.
Spotted slates, 35.
Stair, 27, 30, 31.
Staveley, 49.
Stolzite, 2, 21.
Stonycroft, 6, 15, 27, 28, 32.
Swinburn Gill, 40.

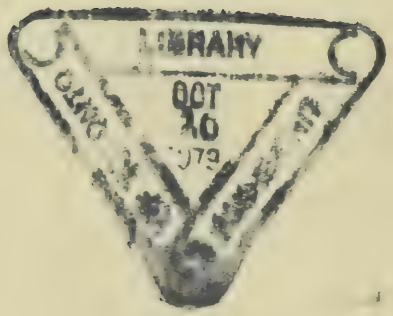
Tertiary rocks, 5.
Thief Gill, 36–39.
Thirlmere, 47.
Thornthwaite, 2,3, 5–7, 9, 27, 31, 33.
———— Mines, Ltd., 7.
Thrang Crags, 49.
Threlkeld, 2, 5, 11, 20.
———— Mining Co., 11.
Tungsten, 41, 42.
Turner, Mr., 7.

Ullswater, 14, 46.
Umber, 37.
Upper Silurian Slates, 1.
Uzzicar, 26, 27.

Veins, general description of, 1–2; *see also* Lodes.
——— Minerals in, 2.

Ward, Clifton, 38.
Water-power, 5, 6, 10, 18, 20, 23, 25, 27, 31, 39, 48.
Whellan, Wm., 36.
Whinny Ridding, 48.
Whitehaven, 6.
Whiteoak Beck, 49.
Wilson, A., 7, 10, 11.
Windermere, 6, 49.
Withe Sike, 33.
Woodend, 11, 14.
Wythburn, 6, 47.

Yewthwaite, 6, 26, 28–30.



SPECIAL REPORTS ON THE MINERAL RESOURCES OF GREAT BRITAIN.

	s.	d.
VOL. I. TUNGSTEN AND MANGANESE ORES. By H. Dewey and C. E. N. Bromehead, B.A., with contributions by T. Eastwood, A.R.C.S., G. V. Wilson, B.Sc., and R. W. Pocock, B.Sc. 59 pp. 2 illustrations. Wrapper - (1915; Edit. 3, *in preparation*)		
VOL. II. BARYTES AND WITHERITE. By R. G. Carruthers, T. Eastwood, A.R.C.S., G. V. Wilson, B.Sc., R. W. Pocock, B.Sc., and D. A. Wray, B.Sc., with contributions by H. Dewey and C. E. N. Bromehead, B.A. 93 pp. 6 illustrations. (1915; Edit. 3, *in preparation*)		
VOL. III. GYPSUM AND ANHYDRITE. By R. L. Sherlock, D.Sc., and B. Smith, M.A.; AND CELESTINE AND STRONTIANITE. By R. L. Sherlock, D.Sc. 64 pp. 4 illustrations. Wrapper. (1915; Edit. 2, 1918)	2	0
VOL. IV. FLUORSPAR. By R. G. Carruthers, R. W. Pocock, B.Sc., and D. A. Wray, B.Sc., with contributions by H. Dewey, and C. E. N. Bromehead, B.A. 39 pp. 2 illustrations. Wrapper - - - - (1916); Edit. 2, 1917)	0	9
VOL. V. POTASH-FELSPAR, PHOSPHATE OF LIME, ALUM SHALES, PLUMBAGO OR GRAPHITE, MOLYBDENITE, CHROMITE, TALC AND STEATITE (SOAPSTONE, SOAP-ROCK AND POTSTONE), DIATOMITE. By A. Strahan, Sc.D., LL.D., F.R.S.; J. S. Flett, D.Sc., LL.D., F.R.S.; and C. H. Dinham, B.A., with contributions by C. T. Clough, M.A.; T. Eastwood, A.R.C.S.; and A. F. Hallimond, B.A. 43 pp. 3 illustrations. Wrapper. (1916; Edit. 2, 1917)	1	0
VOL. VI. REFRACTORY MATERIALS: GANISTER AND SILICA ROCK, SAND FOR OPEN-HEARTH STEEL FURNACES, DOLOMITE. RESOURCES AND GEOLOGY. 241 pp. 3 plates. 8 text figures. Wrapper - - - (1918; Edit. 2, 1920)	7	6
VOL. VII. MINERAL OIL, KIMMERIDGE OIL SHALE, LIGNITES, JETS, CANNEL COALS, NATURAL GAS. ENGLAND AND WALES. 125 pp. 1 plate. 7 text figures. Wrapper (1918; Edit. 2, 1920)	5	0
VOL. VIII. IRON ORES: HÆMATITES OF WEST CUMBERLAND, LANCASHIRE AND THE LAKE DISTRICT. By B. Smith, M.A. 182 pp. 4 plates. 29 text figures. Wrapper - (1919)	9	0
VOL. IX. IRON ORES (*contd.*). SUNDRY UNBEDDED ORES OF DURHAM, EAST CUMBERLAND, NORTH WALES, DERBYSHIRE, THE ISLE OF MAN, BRISTOL DISTRICT AND SOMERSET, DEVON AND CORNWALL. By T. C. Cantrill, B.Sc., R L. Sherlock, D.Sc., and H. Dewey. 87 pp. 7 text figures. Wrapper - - - - - - (1919)	3	6
VOL. X. IRON ORES (*contd.*). THE HÆMATITES OF THE FOREST OF DEAN AND SOUTH WALES. By T. F. Sibly, D.Sc. 93 pp. 14 text figures. Wrapper - - - - - (1919)	4	0
VOL. XI. IRON ORES (*contd.*). THE IRON ORES OF SCOTLAND. By M. Macgregor, B.Sc.; G. W. Lee, D.Sc.; G. V. Wilson, B.Sc.; with contributions by T. Robertson, B.Sc., and J. S. Flett, F.R.S. 240 pp. 18 text figures - - - - (1920)	10	0
VOL. XII. IRON ORES (*contd.*). BEDDED ORES OF THE LIAS, OOLITES AND LATER FORMATIONS IN ENGLAND. By G. W. Lamplugh, F.R.S., C.B. Wedd., B.A., and J. Pringle. 240 pp. 8 plates. 12 text figures. Wrapper - - - (1920)	12	6
VOL. XIII. IRON ORES (*contd.*). PRE-CARBONIFEROUS AND CARBONIFEROUS BEDDED ORES OF ENGLAND AND WALES. By Sir A. Strahan, K.B.E., Sc.D., LL.D., F.R.S.; W. Gibson, D.Sc.; T. C. Cantrill, B.Sc; R. L. Sherlock, D.Sc., and Henry Dewey. 123 pp. 3 plates. 10 text figures. Wrapper (1920)	7	6

	s.	d.
VOL. XIV. REFRACTORY MATERIALS: FIRECLAYS. RESOURCES AND GEOLOGY. 243 pp. 4 plates. 13 text figures. Wrapper (1920)	8	0
VOL. XV. ARSENIC AND ANTIMONY ORES. By Henry Dewey, with contributions by J. S. Flett, O.B.E., LL.D., D.Sc., F.R.S., and G. V. Wilson, B.Sc. 59 pp. 1 plate. 2 text figures. Wrapper - - - - - - (1920)	3	0
VOL. XVI. REFRACTORY MATERIALS: GANISTER AND SILICA ROCK, SAND FOR OPEN-HEARTH STEEL FURNACES, DOLOMITE. PETROGRAPHY AND CHEMISTRY. By Herbert H. Thomas, M.A., Sc.D.; A. F. Hallimond, M.A., and Ernest G. Radley. 115 pp. 7 plates. 6 text figures. Wrapper - - (1920)	5	0
VOL. XVII. THE LEAD, ZINC, COPPER AND NICKEL ORES OF SCOTLAND. By G. V. Wilson, B.Sc., with contributions by John S. Flett, LL.D., F.R.S. 159 pp. 2 plates. 16 text figures. (1921)	7	6
VOL. XVIII. ROCK-SALT AND BRINE. By R. L. Sherlock, D.Sc. 121 pp. 2 plates. 16 text figures. Wrapper - (1921)	5	0
VOL. XIX. LEAD AND ZINC ORES IN THE CARBONIFEROUS ROCKS OF NORTH WALES. By Bernard Smith, M.A. 162 pp. 3 plates. 25 text figures. Wrapper - - - (1921)	5	6
VOL. XXI. LEAD, SILVER-LEAD AND ZINC-ORES OF CORNWALL, DEVON AND SOMERSET. By Henry Dewey. 70 pp. 4 plates. 14 text figures. Wrapper - - - - (1921)		
VOL. XXII. THE LEAD AND ZINC ORES OF THE LAKE DISTRICT. By T. Eastwood, A.R.C.S. 54 pp. 1 plate. 4 text figures. Wrapper - - - - - - (1921)		

In course of Publication.

VOL. XX. LEAD AND ZINC: THE MINING DISTRICT OF NORTH CARDIGANSHIRE AND WEST MONTGOMERYSHIRE. By Prof. O. T. Jones.

VOL XXIII. LEAD AND ZINC ORES IN THE PRE-CARBONIFEROUS ROCKS OF WEST SHROPSHIRE AND NORTH WALES. By Bernard Smith and Henry Dewey.

In Preparation.

VOL. ——. LEAD AND ZINC ORES OF NORTHUMBERLAND, ETC. By Stanley Smith, B.A., D.Sc.

VOL. ——. LEAD AND ZINC ORES OF THE PENNINE DISTRICT. By R. G. Carruthers.

VOL. ——. COPPER ORES OF THE WEST OF ENGLAND. By Henry Dewey.

VOL. ——. COPPER ORES OF THE MIDLANDS, THE LAKE DISTRICT AND NORTH WALES. By Henry Dewey.

VOL. ——. REFRACTORY MATERIALS: FIRECLAYS. CHEMISTRY AND PHYSICAL TESTS. By F. R. Ennos, B.A., and other contributors.

VOL. ——. MINERAL OIL, CANNEL COALS, ETC., OF SCOTLAND.

Printed under the authority of HIS MAJESTY'S STATIONERY OFFICE
By Eyre and Spottiswoode, Ltd., East Harding Street, E.C. 4,
Printers to the King's most Excellent Majesty.

SERIA